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THE UNIVERSITY OF ALBERTA

A LONGITUDINAL INVESTIGATION OF ARRESTED THUMBSUCKING IN CHILDREN

by

© HUGH W. LAMONT

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

IN

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "A Longitudinal Investigation of Arrested Thumbsucking in Children", submitted by Hugh William Lamont in partial fulfilment of the requirements for the degree of Master of Science in Orthodontics.

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ABSTRACT

The effects of thumbsucking on the human dentofacial complex are poorly documented and previous longitudinal studies are noticeably lacking. The purpose of this study was to document the long term skeletal and dental effects that thumbsucking has on children who have been treated to stop the habit.

Longitudinal data which included lateral cephalometric radiographs, dental casts and a recorded visual examination were obtained for thirty-three children at each of three observation periods: while thumbsucking was active; approximately one year later, after thumbsucking had ceased; and current long term records obtained at a mean time of eight and one-half years after the second observation period. Detailed skeletal and dental measurements were performed on tracings of the cephalometric headfilms for each of the three observation periods. In addition, a composite tracing using accepted anatomical landmarks and a straight line polygon composite tracing using the SN reference plane were drawn and studied.

The age thumbsucking stopped, the method used to stop thumbsucking, the time interval between observations, and the type of swallow pattern were statistically evaluated in relation to changes in dental overbite and overjet. The type of appliance used to arrest thumbsucking was also studied in relation to tongue activity during swallowing at the current observation.

The results indicate that neither the age at which thumbsucking stopped nor the type of appliance used to stop thumbsucking significantly altered ($P < 0.05$) overbite or overjet relationships. During the course of treatment, however, the overbite relationship does change significantly

whereas the overjet relationship does not. Children with a retained tongue-thrust swallow had an overbite relationship that was significantly different ($P < 0.05$) from the overbite of children who swallowed without thrusting. The overjet relationship was not significantly different when these two groups were compared. Furthermore, the method used to arrest thumbsucking did not significantly ($P < 0.05$) affect tongue-thrust swallowing.

Naso-maxillary responses, as measured by upper face height changes, were greater in children who were treated early (before 84 months of age) than in those children treated later (after 84 months of age). This indicates that normal vertical growth of the maxillary complex is impeded in children with persistant thumbsucking.

This study suggests that thumbsucking effects skeletal and dental structures and that the earlier thumbsucking stops the more likely the chance for favorable compensatory changes in the facial complex.

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INTRODUCTION

Thumbsucking has been a contentious issue to many people in the past and remains so today. The numerous theories on the etiology, remedies and sequelae of this habit are often contradictory so that both parents and interested health therapists are not entirely effective in dealing with the situation. Many studies on thumbsucking have been done by dentists due to the associated malocclusions presented; but pediatricians, psychologists and speech therapists have also been involved in investigations.

The early reports on the subject, as in most fields of clinical study tended to consist of a case history where treatment was often rationalized by the clinician's hypothesis as to the nature of the problem. More theories were elaborated to explain various aspects of the habit, but controlled studies have been notably absent in the past. It has become quite apparent from previous studies that thumbsucking does produce changes in dento-alveolar structures. However, studies done to date have not clarified whether changes are limited to dento-alveolar structures or whether permanent skeletal changes are also induced. The nature and permanence of any potential skeletal or muscular changes need eludication. The purpose of this investigation was to determine the long term effect on the growth and development of the human dento-facial complex in subjects who had a history of chronic thumbsucking.

LITERATURE REVIEW

Thumbsucking, according to Johnson (1939) could be divided into two categories depending on the position of the thumb in the mouth. In the first category, the child's hand dropped so that a prying action occurred as the thumb was fulcrumed over the lower incisors. The prying action exerted a backward force on the mandible and a forward force on the palate and maxillary alveolus. In the second category, the child did not permit the hand to drop. Instead, pressure was exerted directly upward and outward on the maxillary incisors. The force was often aided by wrapping the fingers over the bridge of the nose.

Swinehart (1938) noticed that, in babies who sucked their thumbs, tongue and cheek action were different from normal nursing actions, and that sometimes the thumb was actively pressed against the palate without a concomitant sucking action. In this situation he felt that the thumb acted merely as an obstruction to the orderly eruption of teeth.

Incidence

The incidence of reported thumbsucking has varied with the selection of the sample, since age (Popovich and Thompson, 1973), size of sample (Traisman and Traisman, 1958) and socioeconomic levels (Anderson et al, 1973) have all been implicated. Traisman and Traisman (1958), after studying 2,650 children, concluded that 45.6 percent had a history of thumbsucking. Popovich and Thompson (1973) reported that the incidence was close to 40 percent at age six years and gradually decreased as children got older, while Anderson et al (1973) indicated that children in higher socioeconomic levels tended to retain thumbsucking habits longer than their counterparts from lower socioeconomic

levels.

Etiology

Ilg and Ames (1955) reported that hand to mouth movement is one in a series of natural movements made by infants up to the age of 1½ years. Graber (1958a) stated that thumb and finger habits were a normal developmental facet for the first 2 to 3 years of life.

Johnson (1939) felt that sucking and its associated habits were developed in relation to hunger and to a lack of opportunity for progressive movements, while Spock (1971) indicated that thumbsucking in early months showed either a need for more food or a need for increased time at feedings. Spock (1971) also indicated that breast and bottle feeding had different effects on a child since breast feeding usually satisfied both hunger and sucking needs, whereas bottle feeding did not. Levy (1937), basing his views on numerous feeding histories and animal behavior, also concluded that the primary cause of thumbsucking was insufficient sucking at breast or bottle. He also found that the percentage of thumbsucking problems was consistent with sucking time and that unscheduled feeders had a better chance of avoiding the habit than scheduled feeders.

Mack (1951), in a summary of the psychological aspects of thumbsucking, indicated that almost all infants had to do a certain amount of sucking to satiate themselves. He also viewed thumbsucking as a retrogressive action and a method of withdrawing from the outside world. Freud's (1918) theory was that thumbsucking was an example of erotic satisfaction in the oral erogenous zone. Davidson et al (1967), on the other hand, supported the theory that a psychological disturbance was

not present, but that a simple habit had been learned.

Effects

Massler and Wood (1949) reviewed the topic of thumbsucking in the literature and concluded that the effects depended on the vigor, duration, and method of sucking as well as the age of the child. Graber (1958a) described the duration, frequency, and intensity of the habit as an important trident of factors that would ultimately contribute to the severity of any deleterious effects from sucking habits.

A study of 38 children with chronic thumbsucking habits (Swinehart, 1938) evaluated by study models, photographs, and roentgenograms indicated a tendency toward maxillary dental protrusion, mandibular incisor retrusion, open bite, narrow arches and a Class II, division 1, malocclusion. Furthermore, the permanence of any malocclusion was considered to be due to pernicious habits of the tongue and lips and also from mouth breathing.

Angle (1907) contended that thumbsucking rarely displaced deciduous teeth but would, if the habit persisted, cause a marked malocclusion of permanent incisors. Alternatively, Case (1921) felt that deciduous teeth could be affected and that a maxillary dental protrusion could be produced with the dental arches becoming narrower but with no changes in the mesiodistal relationships of buccal teeth.

Sillman (1951) with the aid of dental study models visually evaluated 60 children of whom 20 were thumbsuckers. He observed that good occlusions were rarely affected by thumbsucking whereas malocclusions often became more severe in the presence of this habit.

The shift toward a Class II molar relationship was acknowledged

in a serial investigation of study models of thumbsucking children by Ruttle et al (1953). However, the contribution of thumbsucking to the Class II molar relationship was deemed to be small. A further conclusion was that intercuspid arch width often decreased and that inter-molar width was stable. The conclusion about the stability of posterior arch width was also revealed by Bowden (1966). In a longitudinal study of dental casts, Bowden (1966) concluded that if the habit were stopped when the child was 3 years of age or younger, overbite reverted to values seen in non-sucking children. If the habit stopped between the ages 3 and 5 years, the overbite took 5 years to resolve; and if the habit stopped after the child was 5 years of age, there was incomplete resolution of the overbite.

Several hypotheses were advanced to attempt to explain the permanence of the clinically observed malocclusions. Swinehart (1938) and Graber (1963) contended that the individual's musculature was responsible. A more specific explanation was postulated by Haryett et al (1967) who felt that the maxillary dental protrusion was stabilized by an everted lower lip and weakened upper lip, and that a pathologic cycle of compensatory mandibular movements were necessitated in order to effect chewing.

Abnormal mentalis muscle activity in relation to swallowing was divided into two categories by Tulley (1956). Primary abnormal muscle activity was considered to be due to abnormal soft tissue morphology and was not capable of being re-educated. Secondary abnormal muscle, or muscle habit, referred to acquired muscular behavior which was secondary to a malocclusion. Muscle habits were deemed capable of being re-educated when the sensory input from the malocclusion was corrected.

The speculation that muscle contraction patterns were different in thumbsuckers than in non-thumbsuckers was studied by Baril and Moyers (1960) using electromyography. Although no cause and effect relationship could be established between thumb habit and muscle pattern, it was shown that the masseter muscles were very inactive in thumbsuckers when they swallowed. Speculation was presented, therefore, that buccal dental collapse could be due to increased negative pressure from sucking and could be aided by thumb positioning in some individuals.

The origin of tongue thrusting and its possible association with thumbsucking is a controversial subject. Bosma (1972) stated that the stable position of the newborn's tongue was cued by the large area of approximation to the hard and soft palate and, less constantly, to contact with the lower lip. Rix (1946) felt that since thumbsucking was an infantile act, it was natural that the method of swallowing, with tongue thrust, would also be infantile. Straub (1960) contended that bottle feeding of infants was the main contributing factor leading to abnormal swallowing patterns in children and that tongue thrusting and thumbsucking were not related. Proffit (1969) interpreted the tongue thrust associated with anterior openbite as an incomplete transition from the infantile to adult swallowing pattern. Swallowing was considered by Cleall (1965) to be a reproducible but highly individualistic pattern which was executed within the limitation set by local skeletodental configurations. Furthermore, the concept of a tactile sensory component in control of deglutition was supported by evidence that changing the sensory cues in the mouth quickly modified tongue resting posture with movement during swallowing. The fact that these adaptive changes were reversible upon crib removal suggested that reinforcing tactile stimuli

were required at all times to maintain new muscular movement patterns during swallowing. A further statement that tongue position may be cued by sensory inputs was acknowledged by Sublelny (1970) who noticed that the tongue tip maintained a relatively stable position with respect to the incisal edge of lower incisors both before and after treatment of Class II malocclusions. He also had the impression that the tongue tip seemed to maintain a close functional relationship to the lips during most of the swallow and that a sensory relationship had to be achieved to attain and maintain a proper anterior oral seal.

Speech

The difficulties encountered in speaking with a malocclusion have been discussed frequently. Bloomer (1971) indicated that normal speech was possible only with normal tongue movements in normally related structures. Defective speech would result from maladapted movements in either normal or abnormal structures and normal speech was possible in abnormal structures only with adapted movements. These adapted movements resulted in a compensated normal speech. Zlatin (1972) pointed out that an impaired oral sensory function could be a possible etiologic factor in disorders of articulation and disorders of other tongue functions.

The role of enlarged tonsillar tissue in thumbsucking patients has also been questioned. Although tongue thrusting and mouth-breathing are often associated with this habit and could conceivably cause enlarged tonsils, it is also possible that enlarged tonsils could initiate mouth-breathing and abnormal tongue positioning. Linder-Aronson (1975) after comparing children who had undergone adenoidectomy to a control group

hypothesized that dental changes after adenoidectomy were the result of a change from mouth to nose breathing with concomitant changes in lip and tongue posture. Steele, Fairchild, and Ricketts (1968), in a forum on the tonsil and adenoid problem in orthodontics, pointed out that cranial base configuration and allergies were also factors that might alter pharyngeal space, and therefore tongue position.

Treatment of Thumbsucking

Treatment of children to arrest the thumbsucking habit has been closely related to the individual practioner's interpretations of etiologic factors and the urgency of the situation. Mack (1951) summarized his approach to the treatment of psychologically well-adjusted children as follows:

1. Negative training by parents through repeated reminders and manual removal of the thumb from the mouth.
2. Positive training by the parent with a form of reverse psychology.
3. Ill-tasting medicines applied to the thumb.
4. Finger-guards, mittens, elbow splints.
5. Intra-oral appliances of either a removable or fixed type.

Haryett et al (1970) showed that fixed intra-oral appliances were effective means to permanently arrest thumbsucking if left in place at least 6 months.

Although no method for dentists to accurately appraise the temperament of children was given, Mack (1951) warned that neurotic children, or those whose mental state needed adjustment, would likely suffer from increased nervous instability during the course of treatment. Massler

and Wood (1949) felt that therapeutic aids should never be used unless children actually requested that form of treatment. They also felt that devices should never be used as a form of punishment for a bad habit. Since, in their opinion, malocclusion in the mixed or permanent dentitions was not self-correcting, they reasoned that orthodontic intervention was necessary even when the cause could not be removed.

Davidson et al (1967), after studying the psychologic effects of arresting the thumbsucking habit by various means, concluded that the palatal crib failed to produce a significant increase in alternate symptoms. Furthermore, their study failed to support the psychoanalytic interpretation of thumbsucking as a symptom of psychological disturbance.

METHOD AND MATERIALS

The patient sample for this study was derived from a previous study designed to evaluate the effectiveness of various methods of arresting thumbsucking (Haryett et al, 1967) (See Table 1,2). The initial study began in 1964 on thumbsucking children in the City of Edmonton, Alberta. The subjects were persistent thumbsuckers, 4 years of age or older, who displayed changes in occlusion known to result from this habit. Initial pretreatment records including a dental history, results of a visual examination, oriented dental casts, intraoral radiographs and lateral and antero-posterior cephalograms were available for each child.

The children had been randomly divided into 6 groups to study various methods of arresting thumbsucking.

Group 1 - 11 children - no treatment, no psychological support.

Group 2 - 11 children - psychological support.

Group 3 - 11 children - palatal arch.

Group 4 - 11 Children - palatal arch with psychologic support.

Group 5 - 11 children - crib with vertical spurs.

Group 6 - 11 children - crib with spurs with psychological support.

In 1965, an additional group was formed to evaluate the effectiveness of treatment by means of a palatal crib with no spurs.

Group 7 - 27 children - palatal crib, no spurs.

Records were repeated one year after appliances were inserted or treatment had begun.

The present long term study was composed of 33 individuals, 9 males and 24 females, who consented to have additional records taken. Of the group, 21 children had been treated with cribs with spurs, 7

TABLE 1

Original Distribution of Subjects According to Treatment of Thumbsucking and Its Effectiveness

Treatment Categories	Total	Effectiveness After 11 Months: Habit Active	Effectiveness After 11 Months: Habit Arrested
1. Control Group - No Treatment	11	9*	1
2. Psychologic Treatment	11	10	1
3. Palatal Arch	11	10	1
4. Palatal Arch and Psychologic	11	8	3
5. Palatal Crib with Vertical Spurs	11	0	11
6. Crib (spurs) and Psychologic Treatment	11	0	11
7. Crib - No Spurs	27	7	20

*One subject dropped out of control group.

TABLE 2

Percentage of Subjects who Stopped Thumbsucking According to the Time Required to Stop and the Method Employed

Time Required to Stop Thumbsucking	Treatment Method	
	Palatal Crib	Other Methods
1st week	81.8%	33.3%
2nd week - 3rd month	4.6%	0.0%
3rd month and over	13.6%	66.7%
	100.0%	100.0%

children with cribs and no spurs, and 5 children with a palatal arch (see Plates 1, 2 and Table 3). Many children originally in treatment groups 1, 2, 3 or 4 had switched to group 5 after 1 year of unsuccessful treatment in their previous category. The remaining original children had either moved from the area or were not interested in volunteering. Most individuals who did not volunteer had remained in categories 1, 2, 3, or 4 and felt that they had not benefitted from the original treatment.

Clinical History

The record of each individual's previous thumbsucking treatment was verified. As well, an appraisal for general health was made to determine whether or not any individuals had suffered any unusual or chronic diseases that might influence our data.

Clinical Examination

A clinical examination was performed on each individual to determine the following:

Presence of tonsils and when removed if absent.

Indications of traumatic injuries to the face, jaws, or teeth.

Whether any orthodontic treatment had been performed.

Whether any dental extractions had been performed.

Facial profile.

Lip posture in repose - whether competent or incompetent.

Type of breathing - whether nasal or oral.

Tongue position at rest.

Tongue position during swallow.

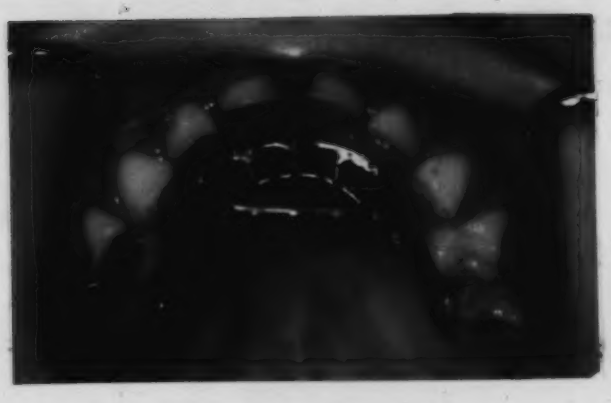
Mentalis muscle activity during swallow - active or passive.

Amount of freeway space.

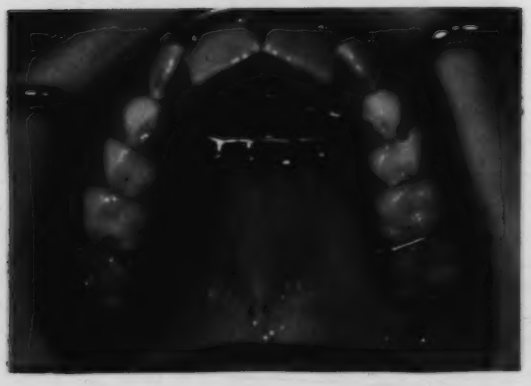
Plate 1

Appliances Used to Arrest Thumbsucking

a) Palatal Arch



b) Palatal Crib



c) Crib with Spurs

Plate 2

Patient Demonstrating Tongue Thrust Swallow

a) Tongue Thrust Swallow

b) Swallow with Crib Placed

TABLE 3

Distribution of Present Sample According to Type of Treatment and Presence of Retained Tongue Thrust

		Without Spurs		With Spurs	
		Palatal Arch	Palatal Crib	Crib with Spurs	Total
Retained Tongue Thrust	No	2	2	11	15
	Yes	3	5	10	18
Totals		5	7	21	33

a.	Without spurs	12	
b.	With spurs		21
c.	Without crib	5	
d.	With crib		28

Mandibular shift on closure. First tooth contact. Extent and direction of shift.

Temporomandibular joint function - by palpation and sound.

Speech - whether "S" sounds were formed clearly and easily.

Any child who had received or was receiving orthodontic treatment was eliminated from the study unless suitable pre-orthodontic treatment records could be obtained.

Evaluation of tongue position was determined by visual means at four different times during the course of the examination by parting the child's lips during a swallow and by careful observation during conversation. The swallowing tongue position was determined during the act of swallowing several mouthfuls of water. Severe thrusts were clinically obvious, but more subtle tongue positioning was subjectively gauged then confirmed by the subject after having been asked to be aware of tongue tip position. Tongue tip position on the lingual surface of the incisal half of the maxillary central incisors or between the incisors during a swallow was considered to be a thrusting position. This definition of tongue thrust is a compromise of the conservative and liberal definitions used by Hanson et al (1969). A conservative tongue thrust was deemed to be one in which the tongue protruded between the teeth; the liberal tongue thrust was considered to be one in which the tongue contacted the teeth to any degree.

Orthodontic Casts

Maxillary and mandibular full arch study casts were made and trimmed to orient the teeth in centric occlusion. No detailed measurements were performed on the casts in the present study.

Cephalometric Roentgenography

All standardized lateral cephalograms were taken with a General Electric machine set to 300 M.A. with the subjects head positioned by means of ear rods in a head holder. The subjects were instructed to close into their normal centric occlusion. Care was taken to ensure that the mandible was not abnormally protruded or opened. The anode to film distance was 60 inches.

Tracing Technique

A tracing of the before treatment, after treatment, and long term cephalograms was made by the same individual on .003 acetate paper with a sharp K3 lead pencil. All bilateral structures were averaged before being traced (Broadbent et al, 1975). Angular measurements were determined to the nearest 0.5 degree and linear measurements were determined to the nearest 0.5 mm. The linear measurements were not corrected for magnification.

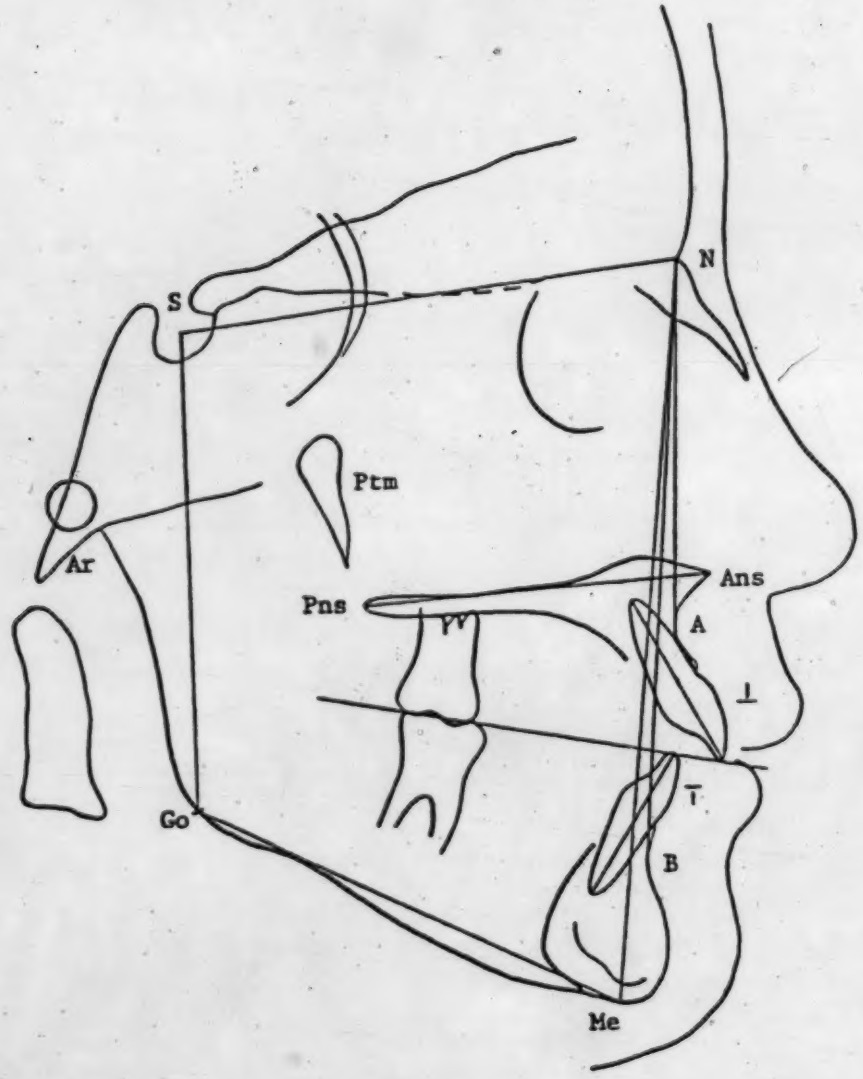
The following landmarks and measurements were determined for each film:

Cephalometric Points (Figure 1)

A	Point "A" Subspinale	The deepest midline point on the maxilla between the Anterior Nasal Spine and Prosthion.
ANS	Anterior Nasal Spine	The tip of the Anterior Nasal Spine which forms the most anterior projection of the floor of the nasal cavity.
Ar	Articulare	The point of intersection of the images of the posterior border of the mandible and the inferior border of the occipital base.
Ba	Basion	The point representing the apex of the image of the anterior margin of the foramen magnum.

FIGURE 1

Cephalometric Landmarks



B	Point "B"	The deepest midline point on the mandibular symphysis.
Go	Gonion	The external angle of the mandible formed by bisecting the angle formed by tangents to the posterior border of the ramus and the inferior border of the mandibular body.
Me	Menton	The most inferior midline point on the mandibular symphysis.
N	Nasion	The most anterior point of the fronto-nasal suture.
PNS	Posterior Nasal Spine	The tip of the posterior nasal spine which forms the posterior projection of the floor of the nasal cavity.
Ptm	Pterygomaxillary Fisure	The outline of the anterior surface of the pterygoid process of the sphenoid bone and the posterior margin of the maxilla.
S	Sella Turcica	The point representing the geometric centre of the pituitary fossa.

Lines and Planes (Figure 1)

MP	Mandibular Plane	The line drawn from point Menton (Me) to point Gonion (Go).
NA	Nasion - Point "A"	The line drawn from point Nasion (N) to Point "A".
NB	Nasion - Point "B"	The line drawn from point Nasion (N) to Point "B".
NMe	Nasion - Menton Anterior Face Height	The line drawn from point Nasion (N) to point Menton (Me).
N-Pal. Pl(UFH)	Nasion - Palatal Plane Upper Face Height	The line drawn from point Nasion (N) to the palatal plane line along NMe.
Pal.Pl Me(LFH)	Palatal Plane - Menton Lower Face Height	The line drawn from palatal plant to point Menton (Me) along line NMe.
Occl. Pl.	Occlusal Plane	The line through one half the cusp height of the first permanent molars and one half the overbite of the incisors. In openbite situations the overlap of the most anterior occluding teeth was used as the anterior point.

Pal. Pl.	Palatal Plane ANS-PNS	The line from point Anterior Nasal Spine to point Posterior Nasal Spine.
$\underline{1}$-NA	Maxillary Incisor - NA	The distance in mm from an extension of the line Nasion - Point "A" - to the incisal edge of the maxillary incisor measured parallel to the occlusal plane.
$\overline{1}$-NB	Mandibular Incisor - NB	The distance from the incisal edge of the mandibular incisor to the line Nasion - Point "B" - measured parallel to the occlusal plane.
O.B.A.	Apparent Overbite (Figure 2,3)	The vertical distance that the incisal edge of the maxillary central incisor overlaps the incisal edge of the mandibular central incisor. Openbite is a negative overbite. Measurements are made perpendicular to the occlusal plane.
O.B.T.	True Overbite	The vertical distance between the incisal edge of the mandibular central incisor and the lingual surface of the maxillary central incisor measured at right angles to the occlusal plane.
O.J.	Overjet	The horizontal distance between the incisal edge of the maxillary central incisor and the labial surface of the mandibular central incisor measured parallel to the occlusal plane.
S-Go	Sella-Gonion Posterior Face Height	The line joining point Sella (S) and point Gonion (Go).

Angles

ANB		The angle formed by intersection of the lines NA and NB. The difference between Angles SNA and SNB.
MP-SN	Mandibular Plane Angle	The angle formed by intersection of the SN line with the mandibular plane.
Occl-SN	Occlusal Plane Angle	The angle formed by intersection of the SN line with the occlusal plane line.
Pal.Pl SN	Palatal Plane Angle	The angle formed by intersection of the SN line with the palatal plane line.
SNA		The angle formed by the lines Sella-Nasion and Nasion - Point "A".

FIGURE 2

Anterior Dental Measurements Depicting Positive Apparent Overbite

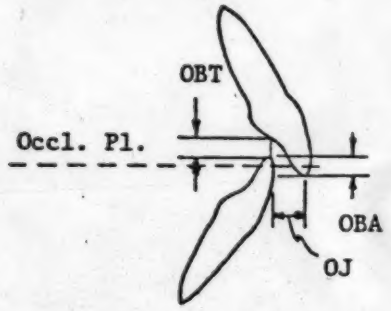
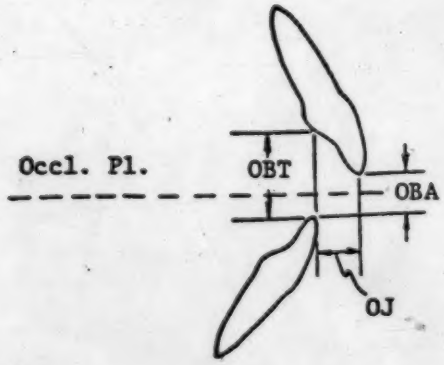


FIGURE 3

Anterior Dental Measurements Depicting Negative Apparent Overbite



SNB		The angle formed by the lines Sella-Nasion and Nasion - Point "B".
$\underline{1}$ - $\overline{1}$	Interincisal Angle	The angle formed by the intersection of the maxillary incisor long axis and mandibular incisor long axis.
$\underline{1}$-SN	Maxillary Incisor Angle	The angle formed by the intersection of the maxillary incisor long axis with the Sella-Nasion line.
$\overline{1}$-MP	Mandibular Incisor Angle	The angle formed by the intersection of the mandibular incisor long axis with the mandibular plane line.
$\underline{1}$-NA	Maxillary Incisor to NA	The angle formed by the intersection of the maxillary incisor long axis with the Nasion - Point "A" line.
$\overline{1}$-NB	Lower incisor to NB	The angle formed by the intersection of the mandibular incisor long axis with the Nasion - Point "B" line.

Superimposition Technique

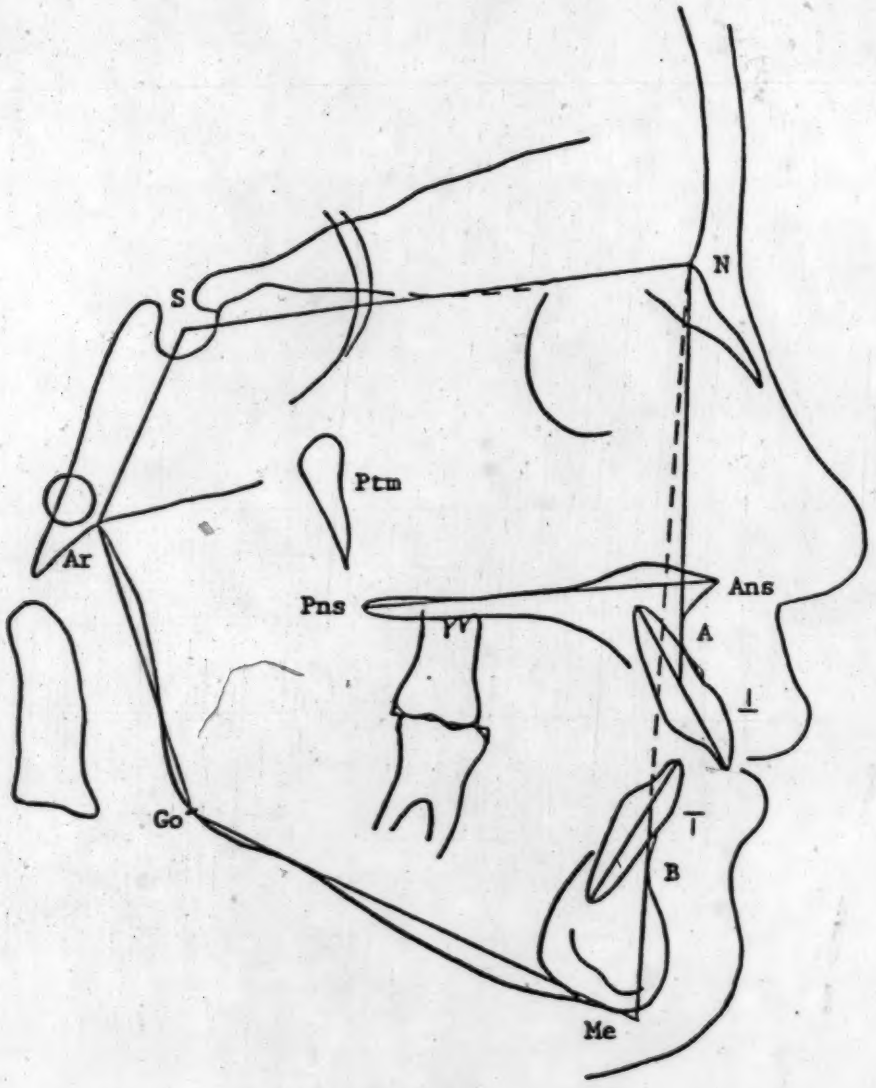
Changes in the craniofacial complex were analyzed by superimposing tracings of the serial lateral cephalograms on the anterior and middle cranial fossae, the cribiform plate, and sella turcica (Moore, 1959), and by aligning the pterygomaxillary fossae as well as possible (Bjork, 1947).

The superimpositions designed to show dental changes in the maxilla were made by aligning the palatal planes and recording at ANS (Moore, 1959).

Mandibular superimpositions were made by aligning the lingual wall of the symphysis and by paralleling the mandibular planes. Consideration was also given to the internal architecture of the symphysis (Moore, 1959). A straight line polygon tracing (Figure 4) was drawn to allow visual inspection of superimpositions on the SN plane with registraction at point Sella. The following lines were used to construct the

FIGURE 4

Example of Polygon Tracing



polygon:

ANS-PNS	Palatal Plane Pal.Pl.	The line joining Anterior Nasal Spine and Posterior Nasal Spine.
Ar-S	Articulare-Sella	The line drawn from point Articulare to point Sella.
Go-Ar	Gonion-Articulare	The line drawn from point Gonion to point Articulare.
Go-Me	Mandibular Plane	The line drawn from point Gonion to point Menton and extending to meet NB.
$\underline{1}$	Maxillary Incisor	The line drawn from the root apex to the incisal tip of the maxillary central incisor.
$\overline{1}$	Mandibular Incisor	The line drawn from the root apex to the incisal tip of the mandibular central incisor.
NA to $\underline{1}$		The line from point Nasion through Point "A" to intersect the long axis of the maxillary central incisor.
NB from $\underline{1}$ to MP		The lower half of line NB from the long axis of the mandibular incisor through Point "B" to the mandibular plane line.
Occl. Pl.	Occlusal Plane	The occlusal plane line at the level of either the first permanent molars or second deciduous molars.
SN	Sella-Nasion	The line drawn from point Sella to point Nasion.

Although many dental and skeletal measurements were recorded in this investigation, the statistical evaluation was limited to the anterior dental relationships of apparent overbite (OBA), true overbite (OBT), and overjet (OJ). The critical level of significance was set at $p < 0.05$.

Research Hypotheses

The following null hypotheses (H_o) were proposed:

H_o1: The age at which thumbsucking is arrested does not affect the apparent overbite (OBA) of central incisors.

H_o2: The presence of vertical spurs in the mouth during treatment of

thumbsucking does not affect the apparent overbite (OBA) of central incisors.

H_o3: The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking does not affect the apparent overbite (OBA) of central incisors.

H_o4 There is no difference in apparent overbite (OBA) of central incisors before treatment, after treatment, and after long term phases of treatment.

H_o5 The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the apparent overbite (OBA) of central incisors.

H_o6: The interaction of the presence of vertical spurs to aid in the arrest of thumbsucking and the phase of treatment does not affect the apparent overbite (OBA) of central incisors.

H_o7: The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the apparent overbite (OBA) of central incisors.

H_o8: The age at which thumbsucking is arrested does not affect the true overbite (OBT) of central incisors.

H_o9: The presence of vertical spurs in the treatment of thumbsucking does not affect the true overbite (OBT) of central incisors.

H_o10: The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking, does not affect the true overbite (OBT) of central incisors.

H_o11: There is no difference in true overbite (OBT) of central incisors before treatment, after treatment, and after long term phase of

treatment.

H_o12: The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the true overbite (OBT) of central incisors.

H_o13: The interaction of the presence of vertical spurs in the treatment of thumbsucking and the phase of treatment does not affect the true overbite (OBT) of central incisors.

H_o14: The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the true overbite (OBT) of central incisors.

H_o15 The age at which thumbsucking is arrested does not affect the overjet (OJ) of central incisors.

H_o16: The presence of vertical spurs in the treatment of thumbsucking does not affect the overjet (OJ) of central incisors.

H_o17: The interaction of the age at which thumbsucking is arrested, and the presence of vertical spurs in the treatment of thumbsucking does not affect the overjet (OJ) of central incisors.

H_o18: There is no difference in overjet (OJ) of central incisors before treatment, after treatment, and after long term phase of treatment.

H_o19: The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the overjet (OJ) of central incisors.

H_o20: The interaction of the presence of vertical spurs in the treatment of thumbsucking and the phase of treatment does not affect the overjet (OJ) of central incisors.

H_o21: The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the overjet (OJ) of central incisors.

H_o22: The mean apparent overbite (OBA) of central incisors in subjects who have stopped thumbsucking is no different in subjects with a tongue thrust swallow than in subjects without a tongue thrust swallow.

H_o23: The mean true overbite (OBT) of central incisors in subjects who have stopped thumbsucking is no different in subjects with a tongue thrust swallow than in subjects without a tongue thrust swallow.

H_o24: The mean overjet (OJ) of central incisors in subjects who have stopped thumbsucking is no different in those subjects with a tongue thrust swallow than in those subjects without a tongue thrust swallow.

H_o25: The placement of a fixed crib appliance to arrest thumbsucking is not related to the retained tongue thrust swallow pattern.

H_o26: The presence of vertical spurs during correction of the thumbsucking habit is not related to the retained tongue thrust swallow pattern.

Statistical Analysis

The major statistical analysis used in the study was a three-way analysis of variance with repeated measures on one factor. The three factors were:

1.0 Age at which thumbsucking ceased. There were two levels (Table 4);

1.1 Below age 84 months (n = 14)

1.2 Above age 84 months (n = 19)

TABLE 4

Distribution of Sample According to Type of Treatment and Age Habit Arrested

Age Habit Arrested	No Spurs		Spurs	
	Palatal Arch	Palatal Crib	Crib with Spurs	Total
Under 84 mo.	2	3	9	14
Over 84 mo.	3	4	12	19
Total	5	7	21	33

(12 no spurs)

2.0 Vertical spurs. There were two levels (Table 4):

2.1 Treatment included vertical spurs on the appliance (n = 21)

2.2 Treatment lacked vertical spurs on the appliance (n = 12).

3.0 Treatment Phase. The group means for each of the three dental measurements being analysed were compared with repeated measures for this factor. The factors were apparent overbite (OBA), true overbite (OBT) and overjet (OJ). The three levels were (Tables 5 and 6):

3.1 Before treatment (n = 33)

3.2 After treatment (n = 33)

3.3 Long term (n = 33)

The differences between the means of dental measurements for those children with a tongue thrust and those children without a tongue thrust were tested by a t-test. The dental measurements tested were apparent overbite (OBA), true overbite (OBT), and overjet (OJ). The group with a retained tongue thrust consisted of 18 children; the group without a tongue thrust consisted of 15 children (Table 3). All children in this sample possessed a tongue thrust before the treatment to arrest thumbsucking began.

The relationship between placement of a fixed crib appliance to arrest thumbsucking and a retained tongue thrust swallowing pattern was tested by the chi-square test. Twenty-eight children had been fitted with the crib appliances. Eighteen children retained a tongue thrust swallowing pattern, and fifteen children changed to a non-thrust swallowing pattern (Table 4).

TABLE 5

Sample Distribution for Analysis of Variance Calculations

	Treatment Phase						
	1		2		3		
	Before Treatment		After Treatment		Long Term		
Age of Thumbsucking Arrest	Spurs	No Spurs	Spurs	No Spurs	Spurs	No Spurs	Totals
Under 84 mo.	9	5	9	5	9	5	14
Over 84 mo.	12	7	12	7	12	7	19
Totals	21	12	21	12	21	12	33

TABLE 6

Age in Months of Subjects for the Three Observation Periods

Observation Period	Mean	Mode	Median	Min.	Max.	Totals
Before Treatment	78.4	59.0	71.0	49.0	120.0	33
After Treatment	90.8	64.0	84.0	60.0	138.0	33
Long Term	193.3	184.0	190.0	107.0	253.0	33

The relationship between the presence of vertical spurs during correction of the thumbsucking habit and presence of a residual tongue thrust swallowing pattern was tested by the Chi-square test. Twenty-one children had been treated with the aid of spurs and twelve children had been treated without the aid of spurs. Eighteen children retained a tongue thrust swallowing pattern and fifteen children changed to a non-thrust swallowing pattern (Table 3).

RESULTS

The cephalometric tracings and accompanying angular and linear measurements for each child are presented in the Appendix Figures 1 to 33. Appendix Figures 1 to 21 represent those children who had a palatal crib with vertical spurs placed to arrest thumbsucking. Those children who wore palatal arches are presented in Appendix Figures 22 to 26 while Appendix Figures 27 to 33 represent those children who wore palatal cribs without spurs.

The cephalometric measurements for the entire group at each of the three phases of treatment are presented as follows:

Table 7 - Before Treatment Measurements

Table 8 - After Treatment Measurements

Table 9 - Long Term Measurements

The analysis of the effect of numerous variables on apparent overbite (OBA) are displayed in Table 10. Analysis of the null hypotheses in relation to apparent overbite are as follows:

H_o1: The age at which thumbsucking is arrested does not affect the apparent overbite (OBA) relationship of central incisors.

The critical F value at the 0.05 level for df = 1, is 4.18. Since the observed F = 0.000, the decision is to accept H_o1.

H_o2: The presence of vertical spurs in the mouth during treatment of thumbsucking does not affect the apparent overbite (OBA) relationship of central incisors.

The critical F value at the 0.05 level for df = 1, is 4.18. Since the observed F = 0.107, the decision is to accept H_o2.

H_o3: The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking

TABLE 7

Cephalometric Measurements of the Entire Sample at the Before Treatment Observation

Dental Measurements	Mean	Standard Deviation	Standard Error
OBA (mm)	-1.061	2.404	0.418
OBT (mm)	-4.061	2.232	0.388
OJ (mm)	4.894	1.911	0.333
$\underline{1}$ - SN (°)	102.045	7.580	1.320
$\overline{1}$ - MP (°)	91.106	8.734	1.520
$\underline{1}$ - $\overline{1}$ (°)	129.985	12.854	2.238
$\underline{1}$ - NA (mm)	3.167	2.259	0.393
$\underline{1}$ - NA (°)	20.455	8.141	1.417
$\overline{1}$ - NB (mm)	3.712	1.640	0.285
$\overline{1}$ - NB (°)	24.152	7.473	1.301
Skeletal Measurements			
SNA (°)	81.121	3.913	0.681
SNB (°)	75.939	3.546	0.617
ANB (°)	5.152	2.283	0.397
Pal.Pl. - SN (°)	7.000	2.867	0.499
Occl.Pl. - SN (°)	20.030	3.742	0.651
MP - SN (°)	37.212	4.232	0.737
S Go (mm)	60.439	5.119	0.891
N Me (mm)	99.879	7.497	1.305
UFH (mm)	44.742	3.509	0.611
LFH (mm)	55.121	4.778	0.832

TABLE 8

Cephalometric Measurements of the Entire Sample at the After Treatment Observation

Dental Measurements	Mean	Standard Deviation	Standard Error
OBA (mm)	0.364	2.349	0.049
OBT (mm)	-2.773	1.842	0.321
OJ (mm)	4.515	2.220	0.386
$\underline{1}$ - SN (°)	100.652	6.809	1.185
$\overline{1}$ - MP (°)	90.242	8.490	1.478
$\underline{1}$ - $\overline{1}$ (°)	132.773	11.510	2.004
$\underline{1}$ - NA (mm)	2.758	2.427	0.423
$\underline{1}$ - NA (°)	19.333	7.271	1.266
$\overline{1}$ - NB (mm)	3.500	1.768	0.308
$\overline{1}$ - NB (°)	22.727	7.346	1.279
Skeletal Measurements			
SNA (°)	80.848	4.022	0.700
SNB (°)	75.773	3.708	0.646
ANB (°)	5.091	2.159	0.376
Pal.Pl. - SN (°)	7.091	3.106	0.541
Occl.Pl. - SN (°)	21.030	4.237	0.738
MP - SN (°)	37.818	5.925	1.031
S Go (mm)	62.379	4.864	0.847
N Me (mm)	102.500	7.517	1.308
UFH (mm)	46.712	4.116	0.716
LFH (mm)	56.848	4.757	0.828

TABLE 9

Cephalometric Measurements of the Entire Sample at the Long Term Observation

Dental Measurements	Mean	Standard Deviation	Standard Error
OBA (mm)	2.621	2.035	0.354
OBT (mm)	-1.606	1.753	0.305
OJ (mm)	4.500	2.750	0.479
$\underline{1}$ - SN (°)	102.697	5.954	1.036
$\overline{1}$ - MP (°)	96.000	7.833	1.364
$\underline{1}$ - $\overline{1}$ (°)	125.909	9.252	1.611
$\underline{1}$ - NA (mm)	5.439	2.800	0.487
$\underline{1}$ - NA (°)	22.576	6.567	1.143
$\overline{1}$ - NB (mm)	5.288	1.719	0.299
$\overline{1}$ - NB (°)	27.939	6.099	1.062
Skeletal Measurements			
SNA (°)	79.818	3.770	0.656
SNB (°)	76.470	4.161	0.724
ANB (°)	3.348	2.248	0.391
Pal.Pl - SN (°)	8.545	3.380	0.588
Occl.Pl. - SN (°)	17.242	5.232	0.911
MP - SN (°)	35.515	5.837	1.016
S Go (mm)	75.909	8.659	1.507
N Me (mm)	120.121	9.559	1.664
UFH (mm)	54.606	4.572	0.796
LFH (mm)	65.518	6.325	1.101

TABLE 10

Analysis of Variance for Apparent Overbite (OBA)

Between Subject Factors	Sum of Squares	Degrees of Freedom	Mean Squares	F Ratio	Probability
A - Age of Habit Arrest	0.005	1	0.005	0.000	0.982
B - Presence of Spurs	1.066	1	1.006	0.107	0.746
AB	0.294	1	0.294	0.030	0.865
Subject Within Groups	289.229	29	9.973		
Within Subject Factors					
C - Observation Period	221.172	2	110.586	34.085	0.001
AC	10.783	2	5.394	1.662	0.199
BC	0.538	2	0.269	0.083	0.921
ABC	5.598	2	2.799	0.083	0.427
C x Subject Within Groups	188.175	58	3.244		

does not affect the apparent overbite (OBA) relationships of central incisors.

The critical F value at the 0.05 level for df = 1 is 4.18. Since the observed F value = 0.030, the decision is to accept H_o4.

H_o4: There is no difference in apparent overbite (OBA) of central incisors before treatment, after treatment, and after long term phases of treatment.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F = 34.085, the decision is to reject H_o3.

H_o5: The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the apparent overbite (OBA) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F = 1.662, the decision is to accept H_o5.

H_o6: The interaction of the presence of vertical spurs to aid in the arrest of thumbsucking and the phase of treatment does not affect the apparent overbite (OBA) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.083, the decision is to accept H_o6.

H_o7: The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the apparent overbite (OBA) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.863, the decision is to accept H_o7.

The analysis of the effect of numerous variables on true overbite (OBT) are shown in Table 11. The analyses of null hypotheses in relation to true overbite (OBT) are as follows:

H_o8: The age at which thumbsucking is arrested does not affect the true overbite (OBT) relationship of central incisors.

The critical F value at the 0.05 level for df = 1 is 4.18. Since the observed F value = 1.677, the decision is to accept H_o8.

H_o9: The presence of vertical spurs in the treatment of thumbsucking does not affect the true overbite (OBT) relationship of central incisors.

The critical F value at the 0.05 level for df = 1 is 4.18. Since the observed F value = 1.967, the decision is to accept H_o9.

H_o10: The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking does not affect the true overbite (OBT) relationship of central incisors.

The critical F value at the 0.05 level for df = 1 is 4.18. Since the observed F value = 0.064, the decision is to accept H_o10.

H_o11: The phase of treatment does not affect the true overbite (OBT) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 18.202, the decision is to reject H_o11.

H_o12: The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the true overbite (OBT) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.059, the decision is to accept H_o12.

TABLE 11

Analysis of Variance for True Overbite (OBT)

Between Subject Factors	Sum of Squares	Degrees of Freedom	Mean Squares	F Ratio	Probability
A - Age of Habit Arrest	10.989	1	10.989	1.677	0.206
B - Presence of Spurs	12.888	1	12.888	1.967	0.171
AB	0.417	1	0.417	0.064	0.803
Subject Within Groups	190.010	29	6.552		
Within Subject Factors					
C - Observation Period	86.549	2	43.275	18.202	0.001
AC	0.279	2	0.139	0.059	0.943
BC	0.623	2	0.311	0.131	0.878
ABC	0.779	2	0.389	0.164	0.849
C x Subject Within Groups	137.892	58	2.377		

H_o13: The interaction of the presence of vertical spurs in the treatment of thumbsucking and the phase of treatment does not affect the true overbite (OBT) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.131, the decision is to accept H_o13.

H_o14: The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the true overbite (OBT) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.164, the decision is to accept H_o14.

The effects of numerous variables on overjet (OJ) are shown in Table 12. The analyses of variance for null hypotheses in relation to overjet are as follows:

H_o15: The age at which thumbsucking is arrested does not affect the overjet (OJ) relationship of central incisors.

The critical F value at the 0.05 level for df = 1 is 4.18. Since the observed F value = 2.322, the decision is to accept H_o15.

H_o16: The presence of vertical spurs in the treatment of thumbsucking does not affect the overjet (OJ) relationship of central incisors.

The critical F value at the 0.05 level for df = 1 is 4.18. Since the observed F value = 0.750, the decision is to accept H_o16.

H_o17: The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking does not affect the overjet (OJ) relationship of central incisors.

The critical F value at the 0.05 level for df = 1 is 4.18. Since the observed F value = 0.069, the decision is to accept H_o17.

TABLE 12

Analysis of Variance for Overjet (OJ)

Between Subject Factors	Sum of Squares	Degrees of Freedom	Mean Squares	F Ratio	Probability
A - Age of Habit Arrest	29.330	1	29.330	2.322	0.138
B - Presence of Spurs	9.473	1	9.473	0.750	0.394
AB	0.866	1	0.866	0.069	0.795
Subject Within Groups	366.287	29	12.631		
Within Subject Factors					
C - Observation Period	4.598	2	2.299	1.233	0.299
AC	1.608	2	0.804	0.431	0.652
BC	1.500	2	0.750	0.402	0.671
ABC	0.284	2	0.142	0.076	0.927
C x Subject Within Groups	108.212	58	1.864		

H_o18: The phase of treatment does not affect the overjet (OJ) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 1.233, the decision is to accept H_o18.

H_o19: The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the overjet (OJ) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.431, the decision is to accept H_o19.

H_o20: The interaction of the presence of vertical spurs in the treatment of thumbsucking and the phase of treatment does not affect the overjet (OJ) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.402, the decision is to accept H_o20.

H_o21: The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the overjet (OJ) relationship of central incisors.

The critical F value at the 0.05 level for df = 2 is 3.16. Since the observed F value = 0.076, the decision is to accept H_o21.

The differences between means of anterior dental measurements for tongue thrusters and non-tongue thrusters is displayed in Table 13. The null hypotheses to test the effect of a residual tongue thrust on the anterior dentition are as follows:

H_o22: The mean apparent overbite (OBA) relationship of central incisors in subjects who have stopped thumbsucking is no different in subjects with a tongue thrust swallow than in subjects without a

TABLE 13

Probabilities of t for Differences between Means for Residual Tongue Thrust

Variable	Residual Tongue Thrust	No. Cases	Mean	Std. Dev.	Std. Err.	df	t Value	2 tail Probability
Overbite (Apparent)	No	15	3.50	1.66	0.43	31	2.43	0.021
	Yes	18	1.89	2.07	0.49			
Overbite (True)	No	15	-1.13	1.27	0.33	31	2.00	0.055
	Yes	18	-2.22	1.76	0.42			
Overjet	No	15	3.80	2.82	0.73	31	-1.35	0.186
	Yes	18	5.08	2.63	0.62			

tongue thrust swallow.

The critical T value at the 0.05 level at df = 31 is 2.040. Since the observed T value = 2.43, the decision is to reject H_o22.

H_o23: The mean true overbite (OBT) relationship of central incisors in subjects who have stopped thumbsucking is no different in subjects with a tongue thrust swallow than in subjects without a tongue thrust swallow.

The critical T value at the 0.05 level at df = 31 is 2.040. Since the observed T value = 2.00, the decision is to accept H_o23.

H_o24: The mean overjet (OJ) relationship of central incisors in subjects who have stopped thumbsucking is no different in those subjects with a tongue thrust swallow than in those subjects without a tongue thrust swallow.

The critical T value at the 0.05 level for df = 31 is 2.040. Since the observed T value = 1.35, the decision is to accept H_o24.

The following hypotheses were tested by the Chi square test at the 0.05 level of significance. Tables 14 and 15 show the frequency of tongue thrust in relation to the type of appliance worn. The null hypotheses for tongue thrust are as follows:

H_o25: The placement of a fixed crib appliance to arrest thumbsucking is not related to the retained tongue thrust swallow pattern.

The critical Chi square valve at the 0.05 level for df = 1 is 3.84. Since the observed Chi square valve = 0.04911, the decision is to accept H_o25.

H_o26: The presence of vertical spurs during correction of the thumbsucking habit is not related to the retained tongue thrust swallow pattern.

TABLE 14

The Relationship Between Tongue Thrust and Crib

	No Crib	Crib	Totals
No Tongue Thrust	2	13	15
	13.3%	86.7%	45.5%
Tongue Thrust	3	15	18
	16.7%	83.3%	54.5%
Totals	5	28	33
	15.2%	84.8%	100%

Corrected Chi Square = 0.049 with 1 degree of freedom

Critical Chi Square at the 0.05 level = 3.84

TABLE 15

The Relationship Between Tongue Thrust and Spurs

	No Spurs	Spurs	Totals
No Tongue Thrust	4	11	15
	26.7%	73.3%	45.5%
Tongue Thrust	8	10	18
	44.4%	55.6%	54.5%
Totals	12	21	33
	36.4%	63.6%	100%

Corrected Chi Square = 0.481 with 1 degree of freedom

Critical Chi Square at the 0.05 level = 3.84

The critical Chi square valve at the 0.05 level for df = 1 is 3.84. Since the observed Chi square = 0.48125, the decision is to accept $H_o 26$.

DISCUSSION

The present study consisted of 33 Edmonton school children who had participated in earlier studies designed to evaluate the effectiveness of various methods to arrest chronic thumbsucking habits. The original study (Haryett et al, 1967) selected children on the basis of their age having been over 4 years and their thumbsucking habit having caused visible alterations in dental alignment.

All children had before treatment records and histories recorded before the treatment phase began. Regardless of the length of time for the habit to be arrested, the appliance was worn a length of time as specified by the child's treatment category. One year after the before treatment records were made, a similar set was made to record changes that had occurred during the year the habit ceased and the appliance was still being worn. If changes occurred, it was assumed that they were due mainly to the cessation of the thumbsucking habit and possibly to the effect of the appliance on the tongue posture. If no changes occurred, it was possible that either no initial skeletal or dental changes were produced by the habit or that a compensatory type of action, possibly by soft tissue, was maintaining the altered skeletodental position.

The average dental changes that took place during the course of the present study are listed in Table 16. The overbite relationships (OBA and OBT) demonstrated a significant change ($P < 0.05$) when comparing the before treatment, after treatment and long term evaluations. The statistical evaluations, Table 10, showed that the overbite measurements were significantly different in the 3 observations for the entire sample.

Individually, however, there was much variation. The variability

TABLE 16

Mean Values of Cephalometric Measurements for the Entire Sample for the Three Observation Periods

Cephalometric Measurement	Observation Period		
Dental	Before Treatment	After Treatment	Long Term
OBA (mm)	-1.061	0.364	2.621
OBT (mm)	-4.061	-2.773	-1.606
OJ (mm)	4.894	4.515	4.500
$\underline{1}$ - SN (°)	102.045	100.652	102.697
$\overline{1}$ - MP (°)	91.106	90.242	96.000
$\underline{1}$ - $\overline{1}$ (°)	129.985	132.773	125.909
$\underline{1}$ - NA (mm)	3.167	2.758	5.439
$\underline{1}$ - NA (°)	20.455	19.333	22.576
$\overline{1}$ - NB (mm)	3.712	3.500	5.288
$\overline{1}$ - NB (°)	24.152	22.727	27.939
Skeletal			
SNA (°)	81.121	80.848	79.818
SNB (°)	75.939	75.773	76.470
ANB (°)	5.152	5.091	3.348
Pal. Pl. - SN (°)	7.000	7.091	8.545
Occl. Pl. - SN (°)	20.030	21.030	17.242
MP - SN (°)	37.212	37.818	35.515
S Go (mm)	60.439	62.379	75.909
N Me (mm)	99.879	102.500	120.121
UFH (mm)	44.742	46.712	54.606
LFH (mm)	55.121	56.848	65.518

of anterior dental relationships is demonstrated by a study of the following figures:

Appendix Figures 1,4,5,7,10,12,28 - very little change. Overbite remained open.

Appendix Figures 3,6,8,13 - continuing improvement.

Appendix Figures 2,9 - initial improvement which later deteriorated.

Mean dental changes (Table 16) indicate that the maxillary central incisors, as measured by $\underline{1}$ - SN (°) and $\underline{1}$ - NA (°), tended to upright during treatment for thumbsucking then procline again after treatment had ceased. Similarly, the mandibular incisors, as measured by $\overline{1}$ - MP (°) and $\overline{1}$ - NB (°), tended to upright during treatment and procline after treatment. The average overjet relationship was not altered very much over the course of the present study.

The children in this study were grouped into two groups according to the age at which thumbsucking stopped. The groups were formed of children above or below 84 months of age in order to compare the effects of treatment on younger children in the primary dentition state to the effects on older children in the mixed dentition stage of dental development. There are weaknesses to comparisons of this type since dental age does not necessarily correlate well with chronologic age (Moorrees et al, 1969). However, it was found that the age at which thumbsucking ceased did not affect the position of anterior teeth. In all three anterior dental relationships studied: apparent overbite, true overbite, and overjet, the measurements failed to show a significant difference (P 0.05) between the younger group and the older group.

Bowden (1966) stated that when thumbsucking stopped in a child who was between 3 and 5 years of age, the overbite relation would

resolve in 5 years. He also felt that if the child stopped thumbsucking after age 5 years, the overbite relationship would remain open. The long term records from the present study indicate that some individuals who stopped thumbsucking before age 5 years (Appendix Figures 4,22) never do obtain a good overbite. Conversely, some children who stopped thumbsucking after age 5 years attained quite deep overbites in subsequent years (Appendix Figures 11,17,31).

The question of whether overbite changes are affected by an eruption of teeth or a skeletal change is worthy of elaboration. It has been shown in this study that the overbite relationships are altered to a significant extent over the course of the observations, Tables 10 and 11. It is suggested that the change in angulation of the incisors plays a role in this improvement ($\underline{1}$ - SN (°), $\underline{1}$ - NA (°), T - MP (°), T - NB (°)). Moore (1970) in a longitudinal study on the effects of thumbsucking in monkeys concluded that the subsequent spontaneous change in overbite relationship was accomplished without "significant growth of the alveolar process or eruption of the incisor teeth". Instead, changes in the vertical growth of the maxillary complex were evident.

The influence of thumbsucking on skeletal structures in humans has been debated often. Swinehart (1938) felt that thumbsucking inhibited the normal vertical growth of the maxilla whereas Taft (1966), upon studying 35 children who were prolonged thumbsuckers, concluded that changes to the maxilla and dentition were not significant but that mandibular posture was affected.

The children in this study demonstrated changes in upper face height during the three observation periods, Table 17. When the group

TABLE 17

UFH Measurements According to Age Habit Arrested During the Three Observation Periods

	Before Treatment	After Treatment	Long Term
Under 84 months	42.786	45.00	55.036
Over 84 months	46.184	47.974	54.289

who stopped thumbsucking at an age less than 84 months is compared to the group who stopped at age over 84 months, there is an interesting trend. The younger group, quite expectedly, has a shorter upper face height at the before treatment observation. At the after treatment observation, the difference between the two groups in upper face height is not as great, while in the long term observation, the group that stopped thumbsucking earlier has a greater upper face height dimension than the group of children who stopped thumbsucking at an older age. This observation would suggest that normal vertical growth of the maxillary complex is impeded in those children who persist in a thumbsucking habit. The present finding tends to support the results of Moore's (1970) study on the effects of thumbsucking on monkeys in which he concluded that the thumb force inhibits normal vertical growth in the maxilla.

The average skeletal measurements for the sample for the entire course of the study are presented in Table 16. As with dental measurements, it is worth discussing some of the individual variations in relation to the overall trends. The relation of the maxilla to the cranium, as registered in angle SNA, showed a continuing retrusion throughout the course of the study (Table 16). Individual measurements, however, demonstrated the following variations:

Appendix Figures 1,7,9,11 - SNA remains constant in treatment, then later decreases.

Appendix Figures 2,10 - SNA remains constant throughout.

Appendix Figure 8 - SNA decreased in treatment, then later increased.

Appendix Figure 5 - SNA decreased in treatment, then stabilized.

The relationship of the mandible to the cranium, as registered in angle SNB, demonstrated little change during treatment, and showed a slight increase after treatment (Table 16). Individual variation ranged from quite a dramatic increase in the relative protrusion of the mandible (Appendix Figures 8,10,17,21,32) to a relative retrusion of the mandible (Appendix Figures 4,5,19).

The ANB angle was, when studying the group trends, reduced during the course of observations, usually from a reduction in SNA, or a protrusion of SNB, or by a combination effect of the two - Appendix Figures 6,30.

The behavior of the palatal plane (Pal. Pl. - SN) as indicated in Table 16 showed a very slight increase in angulation during the treatment phase of the study and a greater increase after treatment. On an individual basis, it was evident that: the palatal plane tipped down at ANS (Appendix Figures 1,10,16,18,20) the palatal plane tipped down at PNS (Appendix Figures 7,8,12,17,28,31) and in some, the palatal plane remained relatively paralled (Appendix Figures 5,24).

The angular relations were not the only interesting facets noticed in the behavior of the palatal plane. In the year between the before treatment and after treatment observations, some changes in palatal plane position, relative to the SN line, were quite extreme. Compare the relatively great change in position in Appendix Figures 4 and 5 with the rather stable position of palatal plane in Appendix Figure 6. It should also be noticed that in those instances where palatal plane descended a great amount in the treatment interval, that the ANB angle remained constant and the mandible was rotated in a clockwise manner (Appendix Figures 4,5).

The mandibular plane (MP-SN) on the average increased slightly during treatment and tended to diminish after treatment. The initial increase may be due to several factors. It could be due to an increase in maxillary downward growth after thumbsucking has been arrested, a tipping of palatal plane, over eruption of molar teeth, muscle morphology and location of muscle insertions on the mandible or an existing undesireable growth pattern, possibly influenced by the thumbsucking habit. The diminution of mandibular plane angle in the long term could be part of the normal growth adjustment made by the mandible to accommodate what may be accelerated vertical midfacial growth (Enlow, 1975). The overeruption of molars could possibly result from altered tongue and mandibular posture. Appliance placement may force certain individuals to compensate for the smaller oral volume by opening their mouths more than normal so that their tongue does not encroach upon pharyngeal space. This action could lead to the increased mandibular plane angle in some individuals - Appendix Figures 12,26. It is therefore advisable that care be taken in the treatment of thumbsucking in individuals with class 11 skeletal patterns and steep mandibular plane angles so that nothing is done to aggravate the divergent growth pattern.

The changes that appear in many of the children in this study should be compared to changes seen in other studies. The present study did not include observations and records made at birth or before thumbsucking started, so it is difficult to determine which changes resulted soley from thumbsucking. The study of facial growth by Brodie (1941) indicated that angular measurements on serial cephalograms of growing children were remarkably stable after the first 1½ years of life. Studies on facial proportions by Meredith et al (1958) indicated a

relatively constant overall pattern with individual variations in growth rates and development. A close study of Brodies (1941) results shows that individual variability was also present even though he showed that, on the basis of means in a serial longitudinal study, facial patterns remained remarkably constant. Moore (1959) pointed out that when the facial growth patterns of individuals are studied, "variation rather than constancy is the rule". The data displayed in this study supports the view that variability predominates.

The alterability of skeletodental patterns has been shown previously. Primate studies revealed that the changes in maxillary growth patterns occurred by adaptive remodelling activity in the sutures (Erickson, 1958). Normal growth of the maxillary complex of Macaca mulatta monkeys follows a rotational pattern in the down and forward movement of the face, whereas the pattern in those monkeys who stopped sucking their thumbs indicated that a downward and backward direction predominates (Erickson, 1958, and Phill, 1959). Histologic study revealed that there were differences in the adaptive depositional activity along the fronto-maxillary suture when histologic material of thumbsucking monkeys were compared to previous reports of non-thumbsucking monkeys (Moore, 1949, and Craven, 1956).

Moore (1970) in a longitudinal study on the effects of thumbsucking in Macaca mulatta monkeys concluded that the thumb force inhibited normal vertical growth in the maxilla. These statements were supported by both cephalometric and histologic evidence. He also concluded that alteration in the pattern of growth of the mandible was produced "indirectly by changes taking place in the maxillary complex".

The difference in reaction of the craniofacial complex of humans

to external forces compared to that of Macaca mulatta is difficult to determine. Weislander (1963) observed changes in the direction of growth in the maxilla and supporting bones after forces had been applied by cervical headgrear treatment to children in the mixed dentition period of dental development. The changes consisted mainly of a clockwise rotation of the sphenoid bone and maxillo-facial complex instead of the more normal downward and forward component of growth. The analysis of certain individuals in the present study reveals that similar alterations to those seen by Moore (1970) are evident. In particular, Appendix Figures 4 and 5 show an unusually large increment of vertical palatal growth and a concommitant alteration in mandibular position. More cephalometric evidence, possibly aided by metallic implants, is needed in this area but the similarity between private studies and the present study indicates that thumbsucking forces do alter human facial bones.

Observations of the parallelism of mandibular plane lines in the present study sometimes varied with the method of overall superimposition used. The ethomoid triad superimposition of serial tracings showed Point Nasion to move forward and upward in a few individuals, forward along SN plane in others, or the more common forward and downward direction reported by Moore (1959). This unusual variation of Nasion affects the relative position of the mandibular plane when the SN (polygon) superimposition is compared to the ethnoid triad superimposition. The polygon tracing in Appendix Figures 1 and 20, therefore, shows that the mandibular plane angle is steeper than seen in the corresponding ethmoid triad superimposition. Conversely, when Nasion grew forward and down in the ethmoid triad superimposition, as in

Appendix Figures 21,32,33, the corresponding tracing displayed a relative decrease in mandibular plane angle.

The effect of thumbsucking on mandibular behavior seen in this study is not as discernable as the effect on the maxillary components. The expected pattern of gonial angle closure is not evident in Appendix Figure 19. It could be possible that either the child stopped thumbsucking at such an age that compensatory gonial remodelling was initiated too late, or that the long standing soft tissue patterns were too deeply entrenched to allow a skeletal alteration. Whatever the reason, the open gonial angle and openbite are obvious. The overall average measurements for this study shows a relatively retruded mandible that tends to initially retrude during the treatment phase, then grows more forward in the long term evaluation. Whether continued thumbsucking would have an arresting affect on condylar growth to produce growth patterns similar to those following disease injury, or the use of certain extra oral force systems, is open for further study (Ricketts, 1975, Sarnat, 1964, and Graber, 1975).

It would appear from the records and observations of this study that the final resolution of overbite to a normal range is closely related to absence of any tongue thrusting that sometimes persists after thumbsucking has ceased. This study showed that the amount of overbite present after thumbsucking had ceased was significantly increased ($P < 0.05$) in the absence of a tongue thrust. The question that arises is whether, in some instances, the open bite was due to tongue thrusting and was not primarily associated with thumbsucking. Accurate measurements of duration, intensity, and frequency of thumbsucking and tongue thrusting that were statistically correlated with incisor position

would be necessary before any conclusions could be drawn.

The adaptation of the tongue to the new sensory environment imposed by the placement of a crib is of clinical interest. Both Rix (1946) and Proffit (1969) felt that tongue thrusting was an infantile act or an incomplete transition from an immature to a mature method of swallowing. Is it reasonable, therefore, to assume that placement of a restriction, by means of a crib, will suffice to effect the transition to a mature swallow? Cleall (1965) noticed that crib placement changed the tongue's sensory cues so that it quickly modified its resting posture and swallowing movements. He also postulated that these reinforcing tactile stimuli were required at all times to maintain new movement patterns since it was evident that the newly induced movements were reversible upon crib removal. The present study supports this claim.

Subtelny (1970) contended that the movement of incisors during orthodontic treatment, to reduce overjet and improve overbite, would cause the tongue and lips to adapt to the new environment and help maintain a mature swallow. The observations in the present study could not clarify this point because the situations are not the same. In this study, the tongue thrust was initially altered by the crib, but since incisors were not orthodontically moved to ideal relationships, an improved, but far from ideal, relationship may still have persisted when the crib was removed. The tongue may then be readapting to this less than ideal relationship. Since the incisors are farther forward in the mouth than the crib can be placed, the tongue must adapt to new sensory imputs when the crib is removed, regardless of how well the incisors were aligned. This new anterior limit of movement could pos-

sibly lead to a regression toward the tongue thrust swallow. Further study in this field is indicated. Based

Based on current information on nerve-muscle interaction, it has been hypothesized that neurotrophic mechanisms can regulate development of peripheral tissues (Dmytruk 1974). Moss (1975) feels that the attainment of adult orofacial forms is a product of the integration of a number of growth processes and regulatory mechanism. He further postulates that orofacial growth can be conceived as:

> "a homeostatically controlled series of processes in which the neural centres regulate the peripheral tissues and the periphery, in turn regulates the centre. There seems to be proof that if we alter the angulation, the length, the position or the degree of active or passive tension within a muscle in either a growing or mature organism, we can reasonably expect to find some reciprocal changes, both within the muscle and, perhaps more importantly, within the skeletal units to which the muscle attaches."

When positional or tension changes are affected in muscles, a series of afferent stimuli are evoked. Guth (1969) demonstrated that changes in muscle fiber types, such as from fast to slow or from aerobic to anaerobic, can be changed by exercise. Furthermore, by altering the afferent input from the muscle, the type of neurotrophic substance that the nerve is producing can be changed because the nerve is altering, via axioplasmic transport, the genomic expression of the muscle.

It seems conceivable then, that postural changes and activity changes in facial muscle tissue induced by a thumbsucking habit could have a similar feedback mechanism which, after an extended period of time, could alter the morphology of the craniofacial complex. While it is obvious from an examination of the results of this study that some facial patterns seem to change quite dramatically when thumbsucking is stopped, it is also obvious that some facial patterns do not seem to

change at all.

It seems possible that in some children the arrested thumbsucking habit was followed by an active change in muscular activity and the subsequent skeletal and dental changes were the result of these new muscular levels of activity. In others, perhaps the skeletal disharmony was too severe to allow a spontaneous change in muscle balance to occur (Appendix Figure 19) or perhaps the habit arresting appliance contributed further inbalanced muscle control by encroaching on the tongue's spatial volume.

The present study is useful to help us appreciate the range of response to the cessation of the thumbsucking habit. Several responses to treatment were recorded and analysed for the group and it must be stressed that, while the variety of responses was averaged to portray a typical response, it is not possible to predict on an individual basis what will happen when thumbsucking stops.

How the aforementioned changes relate to the age of the child at the time thumbsucking is arrested is worthy of further study since in this initial report the younger group appears to have undergone more dramatic skeletodental changes in relation to the older group (Table 17). It would be interesting to discover whether the younger children actually recover from the effects of thumbsucking directly, or whether other factors such as altered breathing patterns or altered muscular actions are required first. The compensations in growth and function in these children will probably never cease to amaze interested investigators and clinicians as it has this investigator. It is through the medium of longitudinal growth studies that the investigator more fully appreciates the scope of individual responses to similar environmental conditions.

Finally, a quotation that tends to place all human studies in their proper perspective (Broadbent et al, 1975):

> "What we think we know today shatters the errors and blunders of yesterday and is tomorrow discarded as worthless.
>
> So we grow from larger mistakes to smaller mistakes - as long as we don't lose courage.
>
> This is true of all therapy; no method is final."
>
> Frederick Jensen

SUMMARY AND CONCLUSIONS

The results of this study suggest the following conclusions:

1. The age at which thumbsucking is arrested does not affect the apparent overbite (OBA) relationship of central incisors.
2. The presence of vertical spurs in the mouth during treatment of thumbsucking does not affect the apparent overbite (OBA) relationship of central incisors.
3. The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking does not affect the apparent overbite (OBA) relationship of central incisors.
4. There is a significant change ($P < 0.05$) in the apparent overbite (OBA) relationship of central incisors when measurements are recorded before treatment, after treatment, and at a long term interval for children who have been treated to arrest thumbsucking.
5. The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the apparent overbite (OBA) relationship of central incisors.
6. The interaction of the presence of vertical spurs to aid in the arrest of thumbsucking and the phase of treatment does not affect the apparent overbite (OBA) relationship of central incisors.
7. The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the apparent overbite (OBA) relationship of central incisors.
8. The age at which the thumbsucking habit is arrested does not

affect the true overbite (OBT) relationship of central incisors.

9. The presence of vertical spurs in the treatment of thumbsucking does not affect the true overbite (OBT) relationship of central incisors.

10. The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking does not affect the true overbite (OBT) relationship of central incisors.

11. There is a significant difference ($P < 0.05$) in the true overbite (OBT) relationship of central incisors when measurements are recorded before treatment, after treatment, and at a long term interval for children who have been treated to arrest thumbsucking.

12. The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect the true overbite (OBT) relationship of central incisors.

13. The interaction of the presence of vertical spurs in the treatment of thumbsucking and the phase of treatment does not affect the true overbite (OBT) relationship of central incisors.

14. The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the true overbite (OBT) relationship of central incisors.

15. The age at which thumbsucking is arrested does not affect the overjet (OJ) relationship of central incisors.

16. The presence of vertical spurs in the mouth during treatment of thumbsucking does not affect the overjet (OJ) relationship of

central incisors.

17. The interaction of the age at which thumbsucking is arrested and the presence of vertical spurs in the treatment of thumbsucking does not affect the overjet (OJ) relationship of central incisors.

18. There is not a significant difference ($P < 0.05$) in the overjet (OJ) relationship of central incisors when measurements are recorded before treatment, after treatment, and at a long term interval for children who have been treated to arrest thumbsucking.

19. The interaction of the age at which thumbsucking is arrested and the phase of treatment does not affect overjet (OJ) relationship of central incisors.

20. The interaction of the presence of vertical spurs in the treatment of thumbsucking and the phase of treatment does not affect the overjet (OJ) relationship of central incisors.

21. The interaction of the age at which thumbsucking is arrested, the presence of vertical spurs in the treatment of thumbsucking, and the phase of treatment does not affect the overjet (OJ) relationship of central incisors.

22. The mean apparent overbite (OBA) relationship of central incisors is significantly different ($P < 0.05$) in those subjects with a tongue thrust swallow compared to the subjects without a tongue thrust swallow.

23. The mean true overbite (OBT) relationship of central incisors is no different in subjects with a tongue thrust swallow than in subjects without a tongue thrust swallow.

The observed T value was very close to the critical T

value for the true overbite measurements. A possible explanation for the fact that apparent overbite (OBA) was different and (OBT) was not might be due to the fact that the true overbite is fairly difficult to read on certain cephalograms. Other factors might be the varying angulations and lingual morphology of certain maxillary central incisors.

It may also be true that the apparent overbite relationships are more easily altered by a tongue thrust since the incisal edges are the parts of each tooth being measured and the incisal edges are influenced more by a thrusting tongue.

24. The presence of a residual tongue thrust does not significantly ($P < .05$) affect the overjet relationship of central incisors.

25. The placement of a fixed crib appliance to arrest thumbsucking is not significantly ($P < 0.05$) related to retained tongue thrust swallowing pattern.

26. The presence of vertical spurs during treatment of thumbsucking is not significantly related to the retained tongue thrust swallowing pattern.

The study indicates that the human response to the treatment of thumbsucking is highly individualistic and that care must be taken to appreciate the subtle variations in adaptive responses to treatment.

BIBLIOGRAPHY

Anderson, D.L., Thompson, G.W. and Popovich, F., 1973. Relation of Socioeconomic Level to Sucking Habits and Tooth Eruption. Am. J. Orthodont. 63: 432 (abst.).

Angle, E.H., 1907. Treatment of Malocclusions of the Teeth. Philadelphia, S.S. White Mfg. Co., 7th ed.

Baril, C. and Moyers, R.E., 1960. An Electromyographic Analysis of the Temporalis Muscles and Certain Facial Muscles in Thumb and Finger Sucking Patients. J. Dent. Res. 39: 536-553.

Bjork, A., 1947. The Face in Profile. Svensk Tandl-Tidskrift, 40: Suppl. 5B.

Bjork, A., 1955. Facial Growth in Man Studied with the Aid of Metallic Implants. Acta Odontol. Scand. 13: 9-34.

Bjork, A., 1962. Facial Growth in Bilateral Hypoplasia of the Mandibular Condyles. Vistas in Orthodontics. B.S. Kraus and R.A. Riedel, (editors). Philadelphia, Lea and Febiger.

Bjork, A. and Skieller, V., 1972. Facial Development and Tooth Eruption. Am. J. Orthodont. 62: 339-383.

Bloomer, H.H., 1971. Speech Defects Associated with Dental Abnormalities and Malocclusions. Handbook of Speech Pathology and Audiology. New York. Appleton-Century Crofts, p. 716.

Bosma, J.F., 1972. Form and Function in the Infant's Mouth and Pharynx. Oral Sensation and Perception. Third Symposium, The Mouth of the Infant. J.F. Bosma (Ed.), Springfield, Ill., C.C. Thomas.

Bowden, B.D., 1966. Thumbsucking Effects of Digital and Dummysucking on Arch Widths, Overbite, and Overjet. Aust. Dent. J. 11: 396-404.

Broadbent, B.H. Sr., Broadbent, B.H. Jr. and Golden, W.H., 1975. Bolton Standards of Dentofacial Developmental Growth. Saint Louis, C.V. Mosby Co.

Brodie, A.G., 1941. On the Growth Pattern of the Human Head from the Third Month to the Eighth Year of Life. Am. J. Anat. 68: 209-262.

Case, C.S., 1921. A Practical Treatise on the Techniques and Principles of Dental Orthopedia and Prosthetic Correction of Cleft Palate. Chicago, C.S. Case Co.

Cleall, J.F., 1965. Deglutition: A Study of Form and Function. Am. J. Orthodont. 51: 566-594.

Craven, A.H., 1956. Growth in Width of the Head of the Macaca rhesus Monkey as Revealed by Vital Staining. Am. J. Orthodont. 42: 341-362.

Davidson, P.O., Haryett, R.D., Sandilands, M. and Hansen, F.C., 1967. Thumbsucking: Habit or Symptom? J. Dent. Child. 33: 252-259.

Dmytruk, R.J., 1974. Factors Affecting Neuromuscular Plasticity of Depressor Masticatory Muscles of Monkey. M.S.D. Thesis, University of Washington, Seattle.

Enlow, D.H., 1975. Rotations of the Mandible During Growth. Determinants of Mandibular Form and Growth. Monograph 4 Craniofacial Growth Series. J.A. McNamara Jr. (ed.). Center for Human Growth and Development. University of Michigan, Ann Arbor.

Erickson, L.C., 1958. Facial Growth in the Macaque Monkey: A Longitudinal Cephalometric Roentgenographic Study Using Metallic Implants. M.S.D. Thesis, University of Washington.

Freud, S., 1918. Three Contributions to the Theory of Sex. Nervous and Mental Disease Publishing Co., Third Edition, New York.

Graber, L.W., 1975. The Alterability of Mandibular Growth. Determinants of Mandibular Form and Growth. Monograph 4 Craniofacial Growth Series. McNamara (ed.). Center for Human Growth and Development. University of Michigan, Ann Arbor.

Graber, T.M., 1958a. Extrinsic Factors. Am. J. Orthodont. 44: 26-45.

Graber, T.M., 1958b. Fingersucking Habit and Associated Problems. J. Dent. Child. 25: 145-151.

Graber, T.M., 1963. Muscles, Malformation and Malocclusion. Am. J. Orthodont. 49: 418-450.

Guth, L., 1969. "Trophic" Effects of Vertebrate Neurons. Neurosci. Res. Prog. Bull. 7: 55.

Hanson, M.L., Barnard, L.W. and Case J.L., 1969. Tongue-Thrust in Preschool Children. Am. J. Orthodont. 56: 60-69.

Haryett, R.D., Hansen, F.C., Davidson, P.O. and Sandilands, M., 1967. Chronic Thumbsucking: The Psychologic Effects and the Relative Effectiveness of Various Methods of Treatment. Am. J. Orthodont. 53: 569-598.

Haryett, R.D., Sandilands, M. and Davidson, P.O., 1968. Relative Effectiveness of Various Methods of Arresting Thumbsucking. J. Can. Dent. Assoc. 34: 5-10.

Haryett, R.D., Hansen, F.C. and Davidson, P.O., 1970. Chronic Thumbsucking. Am. J. Orthodont. 57: 164-178.

Ilg, F.L. and Ames, L.B., 1955. Child Behavior. New York, Harper and Row.

Johnson, L.R., 1939. The Status of Thumbsucking and Fingersucking. J. Am. Dent. Assoc. 26: 1245-1254.

Kraus, B.S., Wise, W.J. and Frei, R.H., 1959. Heredity and the Craniofacial Complex. Am. J. Orthodont. 45: 172-217.

Levy, D.M., 1937. Thumb and Finger Sucking from the Psychiatric Angle. Angle Orthodont. 7: 100-103.

Lewis, S.J., 1930. Thumbsucking: A Cause of Malocclusion in the Deciduous Teeth. J. Am. Dent. Assoc. 17: 1060-1073.

Linder-Aronson, S., 1975. Effects of Adenoidectomy on the Dentition and Facial Skeleton Over a Period of Five Years. Transactions of the Third International Orthodontic Congres. J.T. Cook (ed.). Saint Louis, C.V. Mosby Co.

Mack, E.S., 1951. The Dilema in the Management of Thumbsucking. J. Am. Dent. Assoc. 43: 33-45.

Massler, M. and Wood, A.W.S., 1949. Thumbsucking. J. Dent. Child. 16: 1-9.

Meikle, M.C., 1970. The Effect of a Class 11 Intermaxillary Force on the Dentofacial Complex in the Adult Macaca mulatta Monkey. Am. J. Orthodont. 58: 323-340.

Meredith, H.V., Knott, V.B. and Hixon, E.H., 1958. Relation of the Nasal and Subnasal Components of Facial Height in Childhood. Am. J. Orthodont. 44: 285-294.

Minium, E.W., 1970. Statistical Reasoning in Psychology and Education. Toronto, John Wiley and Sons, Inc.

Moore, A.W., 1949. Head Growth of the Macaque Monkey by Vital Staining. Am. J. Orthodont. 35: 654-671.

Moore, A.W., 1959. Observations on Facial Growth and Its Clinical Significance. Am. J. Orthodont. 45: 399-423.

Moore, A.W., 1971. Cephalometrics as a Diagnostic Tool. J. Am. Dent. Assoc. 82: 775-781.

Moore, G.J., 1970. A Longitudinal Study of Thumbsucking and Open Bite in the Macaca mulatta. M.S.D. Thesis, University of Washington.

Moorrees, C.F.A., Gron, A., Lebret, L.M.L., Yen, P.K.J. and Frohlick, F.J., 1969. Growth Studies of the Dentition: A Review. Am. J. Orthodont. 55: 600-616.

Moss, M.L., 1975. Neurotrophic Regulation of Craniofacial Growth.

Control Mechanisms in Craniofacial Growth. Monograph 3. J.A. McNamara, Jr. (ed.). Craniofacial Growth Series. Center for Human Growth and Development. University of Michigan. Ann Arbor.

Pihl, E.B., 1959. A Serial Study of the Growth of Various Cranial and Facial Bones in the Macaque Monkey. M.S.D. Thesis, University of Washington.

Popovich, F. and Thompson, G.W., 1973. Thumb and Finger Sucking: Its Relation to Malocclusion. Am. J. Orthodont. 63: 148-155.

Proffit, W.R., Chastain, B.B. and Norton, L.A., 1969. Linguopalatal Pressure in Children. Am. J. Orthodont. 55: 154-166.

Ricketts, R.M., 1960. The Influence of Orthodontic Treatment on Facial Growth and Development. Angle Orthodont. 30: 103-133.

Ricketts, R.M., 1975. Mechanisms of Mandibular Growth: A Series of Inquiries on the Growth of the Mandible. Determinants of Mandibular Form and Growth. J.A. McNamara, Jr. (ed.). Monograph 4, Craniofacial Growth Series. Center for Human Growth and Development. University of Michigan, Ann Arbor.

Rix, R.E., 1946. Deglutition and the Teeth. Dent. Record 66: p.103.

Ruttle, A.T., Quigley, W., Crouch, J.T. and Ewan, G.E., 1953. Serial Study of the Effects of Fingersucking. J. Dent. Res. 32: 739-748.

Sarnat, B.G., 1964. The Temporomandibular Joint. Springfield, Ill. Charles C. Thomas. p.193.

Sillman, J.H., 1951. Thumbsucking and the Dentition: A Serial Study. N. Y. State Dent. J. 17: 493-502.

Spock, B., 1971. Baby and Child Care. Richmond Hill, Simon and Schuster of Canada, Ltd.

Steele, C.H., Fairchild, R.C. and Ricketts, R.M., 1968. Forum on the Tonsil and Adenoid Problem in Orthodontics. Am. J. Orthodont. 54: 485-512.

Straub, W.J., 1960. Malfunction of the Tongue, Part 1. Am. J. Orthodont. 46: 404-424.

Subtelny, J.D., 1970. Malocclusions, Orthodontic Corrections and Orofacial Muscle Adaptation. Angle Orthodont. 40: 170-199.

Swinehart, E.W., 1938. Relation of Thumbsucking to Malocclusion. Am. J. Orthodont. 24: 509-521.

Taft, L.L., 1966. A Diagnostic Study of the Dentition. Dentofacial Pattern and Cranial Base of Prolonged Thumbsuckers. Am. J.

Orthodont. 52: 703-705. (abst.)

Traisman, A.S. and Traisman, H.W., 1958. Thumb and Fingersucking: A Study of 2,650 Infants and Children. J. Pediat. 52: 566-572.

Tulley, W.J., 1956. Adverse Muscle Forces. Am. J. Orthodont. 42: 801-814.

Wieslander, L., 1963. The Effect of Orthodontic Treatment on the Concurrent Development of the Craniofacial Complex. Am. J. Orthodont. 49: 15-27.

Zlatin, M.A., 1972. Development of Speech, Language, Auditory and Oral Function in the Presence of Congenital Sensory Neuropathy. Third Symposium on Oral Sensation and Perception. J.F. Bosma (ed.). Springfield, Ill., Charles C. Thomas.

APPENDIX

DENTAL MEASUREMENTS

	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-7	-2.0	-4.0	5.0	102.0	89.0	130.5	0.0	16.0	4.5	25.5
After Treatment	6-8	-3.0	-5.0	6.0	101.0	81.5	139.0	2.0	15.0	4.0	17.0
Long Term	15-10	+1.0	-4.0	7.0	100.0	96.0	122.5	6.0	21.0	5.5	32.0

SKELETAL MEASUREMENTS

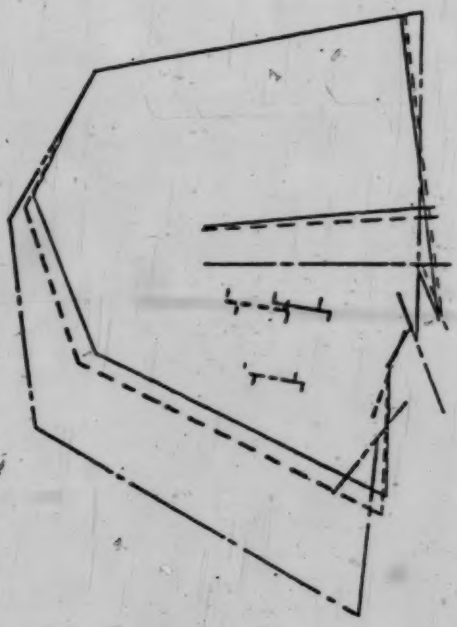
	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	5-7	86.5	78.0	7.5	5.0	21.0	38.0	61.0	100.5	42.5	58.0
After Treatment	6-8	87.0	77.5	10.0	7.0	22.0	39.0	63.0	105.0	45.0	60.0
Long Term	15-10	79.0	74.5	4.5	10.0	22.0	42.0	78.5	129.0	55.0	74.0

APPENDIX TABLE 1 PATIENT #1

APPENDIX FIGURE 1

Patient # 1 Female

Age Therapy Started	5-7
Time Appliance Worn	11 mo.
Age Habit Stopped	5-7
Age Tonsils Removed	5-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes



Before Treatment ——————
After Treatment - - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

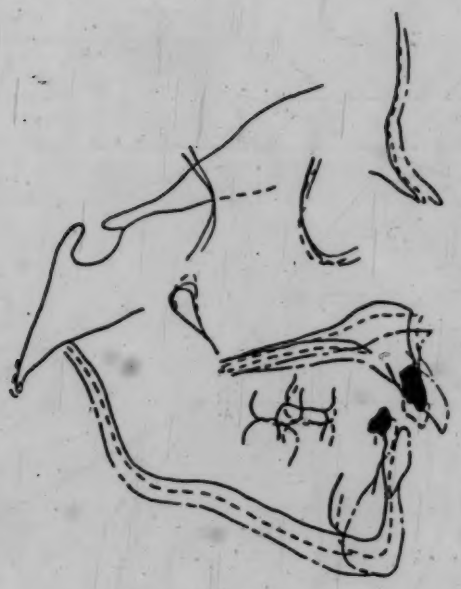
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-8	+0.5	-4.5	6.0	105.5	84.5	148.0	1.0	10.0	1.0	15.0
After Treatment	6-8	+2.0	-2.5	5.0	102.5	85.0	151.0	-1.0	6.0	1.5	16.0
Long Term	8-11	0.0	-5.0	7.0	100.5	86.0	131.0	1.5	14.0	5.0	28.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	5-8	75.0	68.0	7.0	7.0	25.0	42.0	48.0	89.5	41.5	48.0
After Treatment	6-8	76.0	69.0	7.0	7.0	25.0	42.5	51.0	93.5	43.5	50.0
Long Term	8-11	74.0	68.5	5.5	9.0	34.0	43.5	52.5	99.0	47.5	51.5

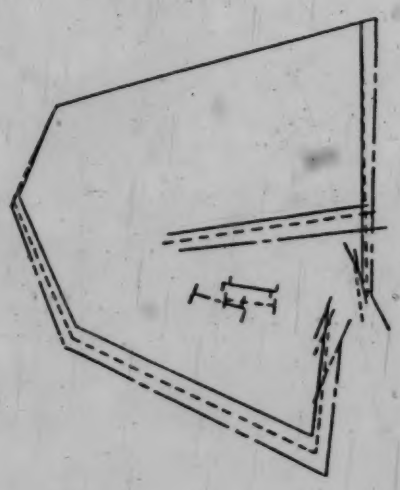
APPENDIX TABLE 2 PATIENT #2

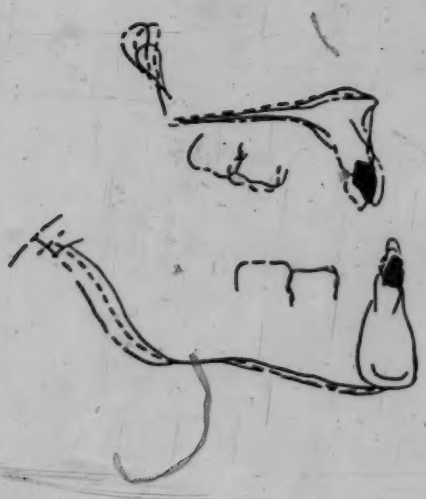
APPENDIX FIGURE 2



Patient # 2 Female

Age Therapy Started	5-8
Time Appliance Worn	6 mo.
Age Habit Stopped	5-8
Age Tonsils Removed	4-2
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No





Before Treatment ———
After Treatment - - - - -
Long Term —— — ——

DENTAL MEASUREMENTS

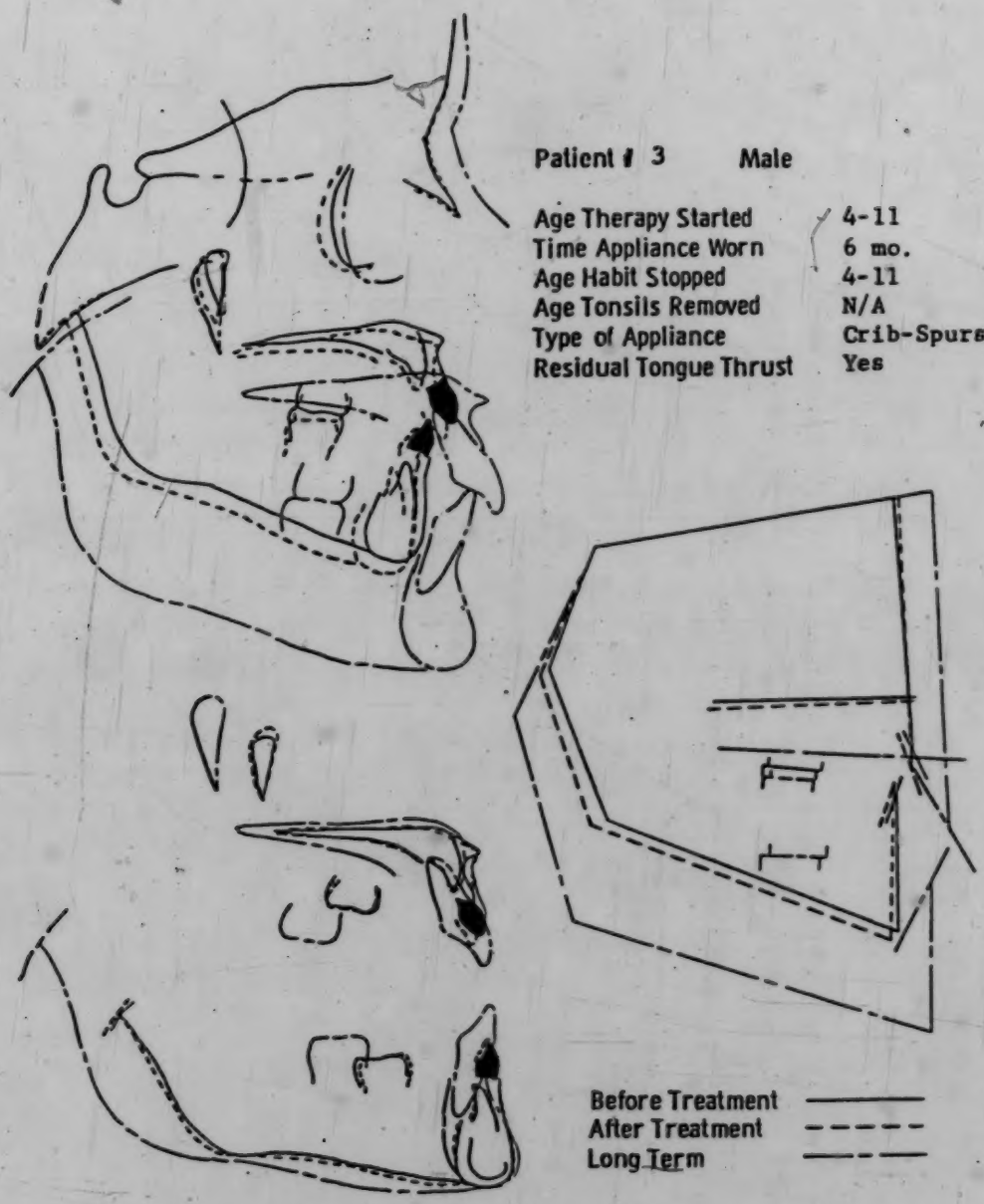
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-11	+0.5	-2.0	4.0	103.0	83.0	142.0	3.0	17.5	2.0	16.0
After Treatment	5-11	+2.0	-2.0	4.0	100.0	84.0	145.0	1.0	16.0	1.0	15.0
Long Term	15-2	-5.0	0.0	5.0	110.0	98.0	124.5	5.0	27.0	4.0	26.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	4-11	85.0	81.5	3.5	8.5	15.0	32.0	59.0	92.5	44.0	48.5
After Treatment	5-11	83.5	79.5	4.0	7.5	14.0	32.5	60.5	95.0	45.0	50.0
Long Term	15-2	83.5	80.5	3.0	12.5	12.0	28.0	82.0	118.0	58.0	60.0

APPENDIX TABLE 3 PATIENT #3

APPENDIX FIGURE 3



Patient # 3 Male

Age Therapy Started	4-11
Time Appliance Worn	6 mo.
Age Habit Stopped	4-11
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term ——— — ———

DENTAL MEASUREMENTS

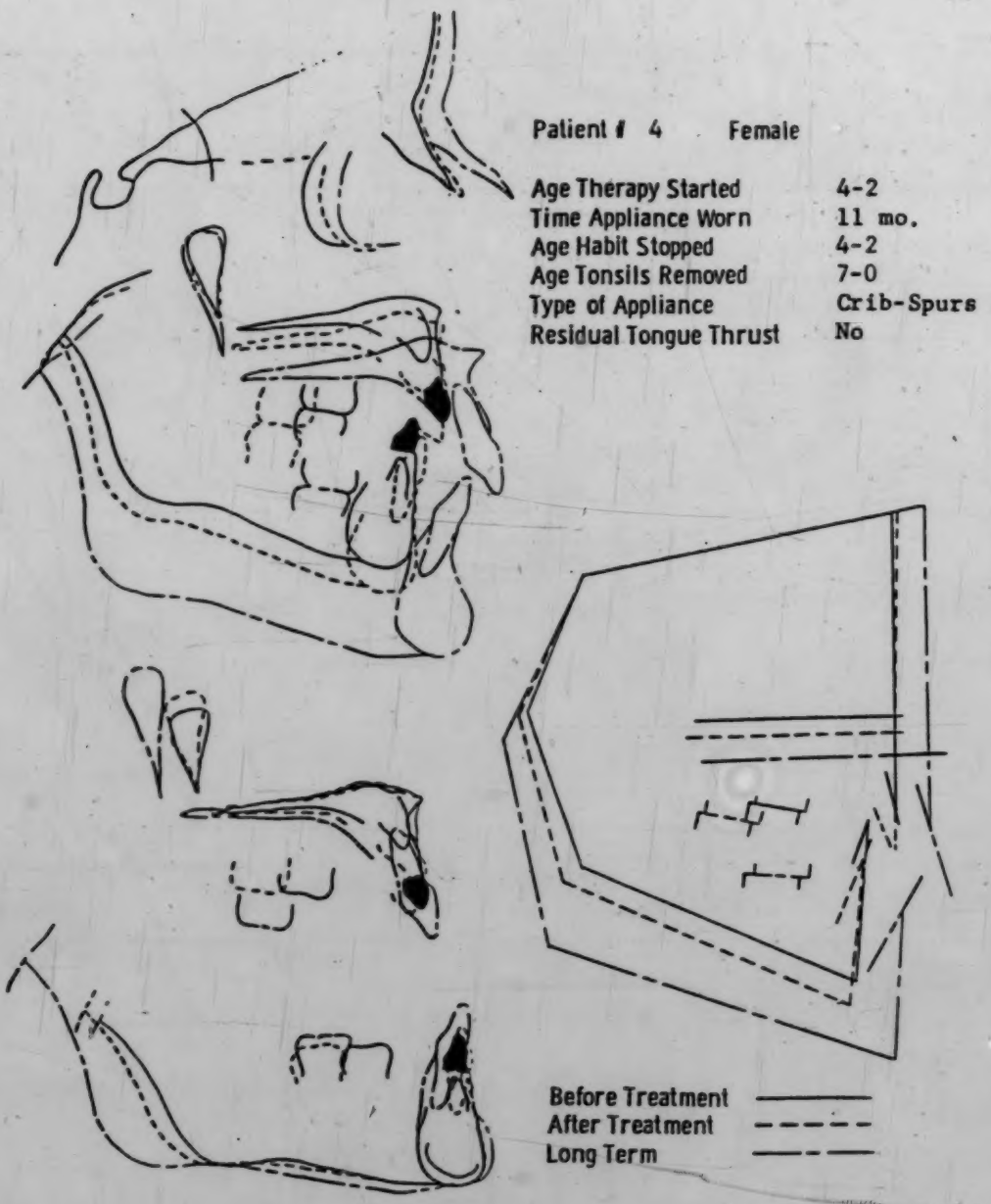
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-2	+0.5	-3.5	5.0	94.0	91.0	140.0	1.5	13.0	2.0	22.0
After Treatment	5-3	0.0	-3.5	5.0	90.0	85.0	150.0	0.0	11.0	1.0	9.5
Long Term	15-5	+4.0	-2.0	5.5	95.0	98.5	134.0	4.0	15.0	4.0	26.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	4-2	80.5	75.5	5.5	10.0	18.5	35.0	63.0	98.5	45.0	53.5
After Treatment	5-3	79.5	74.0	5.5	10.5	22.5	36.0	65.0	103.0	46.5	56.5
Long Term	15-5	79.5	75.5	4.0	10.0	16.0	33.0	84.0	123.0	56.0	67.0

APPENDIX TABLE 4 PATIENT #4

APPENDIX FIGURE 4



Patient # 4 Female

Age Therapy Started	4-2
Time Appliance Worn	11 mo.
Age Habit Stopped	4-2
Age Tonsils Removed	7-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No

Before Treatment
After Treatment
Long Term

DENTAL MEASUREMENTS

	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	6-3	-1.5	-7.5	9.0	92.0	83.0	138.5	2.0	18.5	2.0	15.5
After Treatment	7-4	+2.5	-5.0	11.0	99.5	80.5	137.0	4.5	22.5	2.0	14.0
Long Term	13-2	+5.0	-2.0	11.0	105.0	88.5	120.0	11.5	34.5	6.0	22.5

SKELETAL MEASUREMENTS

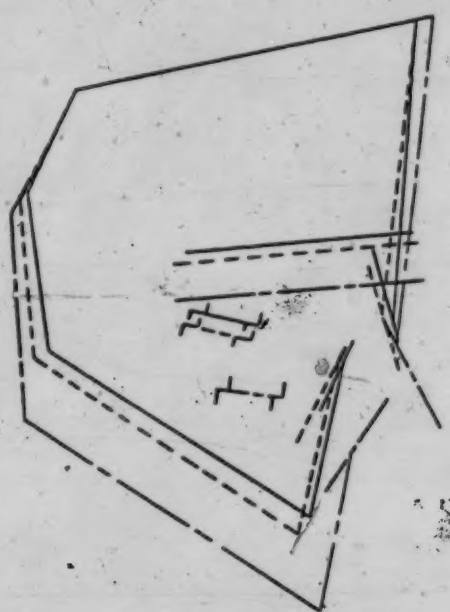
	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo	N Me	UFH	LFH
Before Treatment	6-3	74.0	67.0	7.0	7.0	26.5	46.0	57.5	109.0	49.0	60.0
After Treatment	7-4	72.0	66.0	6.0	7.0	27.0	47.0	60.0	113.0	52.0	61.0
Long Term	13-2	72.0	68.0	4.0	7.0	19.5	46.0	73.5	131.0	60.0	71.0

APPENDIX TABLE 5 PATIENT #5

APPENDIX FIGURE 5

Patient # 5 Male

Age Therapy Started	6-3
Time Appliance Worn	6 mo.
Age Habit Stopped	9-0
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No



Before Treatment ——————
After Treatment - - - - - -
Long Term ——— — ———

DENTAL MEASUREMENTS

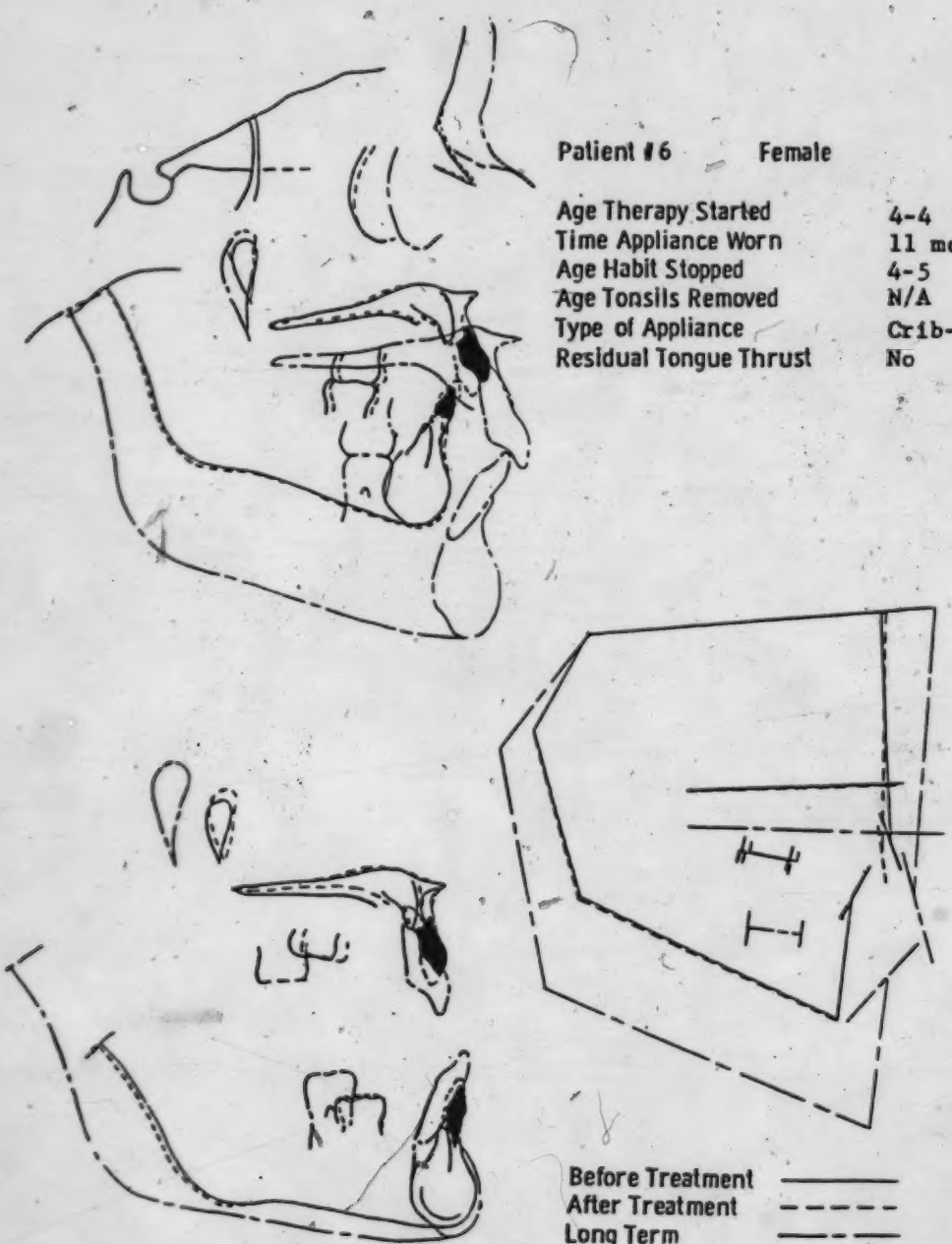
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-4	-2.0	-5.0	6.0	105.0	88.0	136.0	1.5	16.0	3.0	20.0
After Treatment	5-4	+2.5	-1.0	2.5	95.0	94.0	140.0	1.5	10.0	3.5	23.5
Long Term	15-6	+4.0	-0.5	3.0	100.0	106.0	125.0	5.0	18.0	6.0	34.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	4-4	88.0	80.0	8.0	3.0	16.0	31.5	57.5	88.0	38.5	49.5
After Treatment	5-4	85.0	79.0	6.0	3.0	18.0	31.5	58.0	89.0	39.0	50.0
Long Term	15-6	81.5	78.5	3.0	6.5	12.5	30.0	78.5	115.5	50.5	65.0

APPENDIX TABLE 6 PATIENT #6

APPENDIX FIGURE 6



Patient #6 Female

Age Therapy Started	4-4
Time Appliance Worn	11 mo.
Age Habit Stopped	4-5
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No

Before Treatment ——————
After Treatment - - - - -
Long Term —— - ——

DENTAL MEASUREMENTS

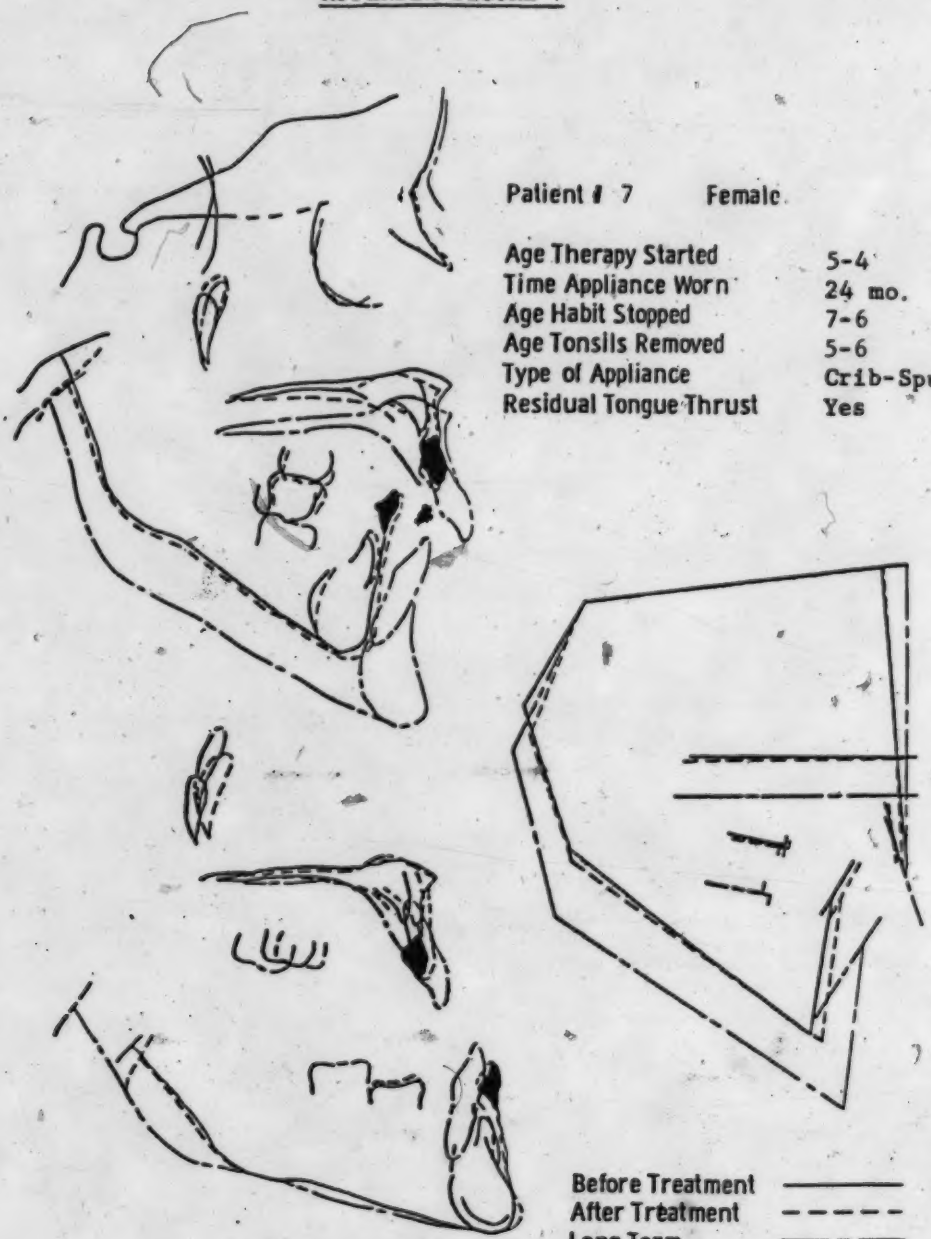
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-4	-2.0	-6.0	7.0	88.0	82.0	146.0	-1.0	2.0	3.0	23.0
After Treatment	6-4	-2.0	-5.0	6.0	97.0	76.0	144.0	0.0	10.0	2.0	16.0
Long Term	12-0	0.0	-6.0	7.0	102.0	86.0	130.0	3.5	19.0	3.0	25.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	5-4	87.0	76.5	10.5	6.0	17.0	44.0	57.0	101.0	43.0	58.0
After Treatment	6-4	87.0	77.0	10.0	6.0	21.0	44.0	60.5	104.0	44.0	60.0
Long Term	12-0	83.0	77.0	6.0	6.5	19.5	42.5	69.0	118.0	51.0	67.0

APPENDIX TABLE 7 PATIENT #7

APPENDIX FIGURE 7



Patient # 7 Female

Age Therapy Started	5-4
Time Appliance Worn	24 mo.
Age Habit Stopped	7-6
Age Tonsils Removed	5-6
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ———
After Treatment - - - - -
Long Term —— - ——

DENTAL MEASUREMENTS

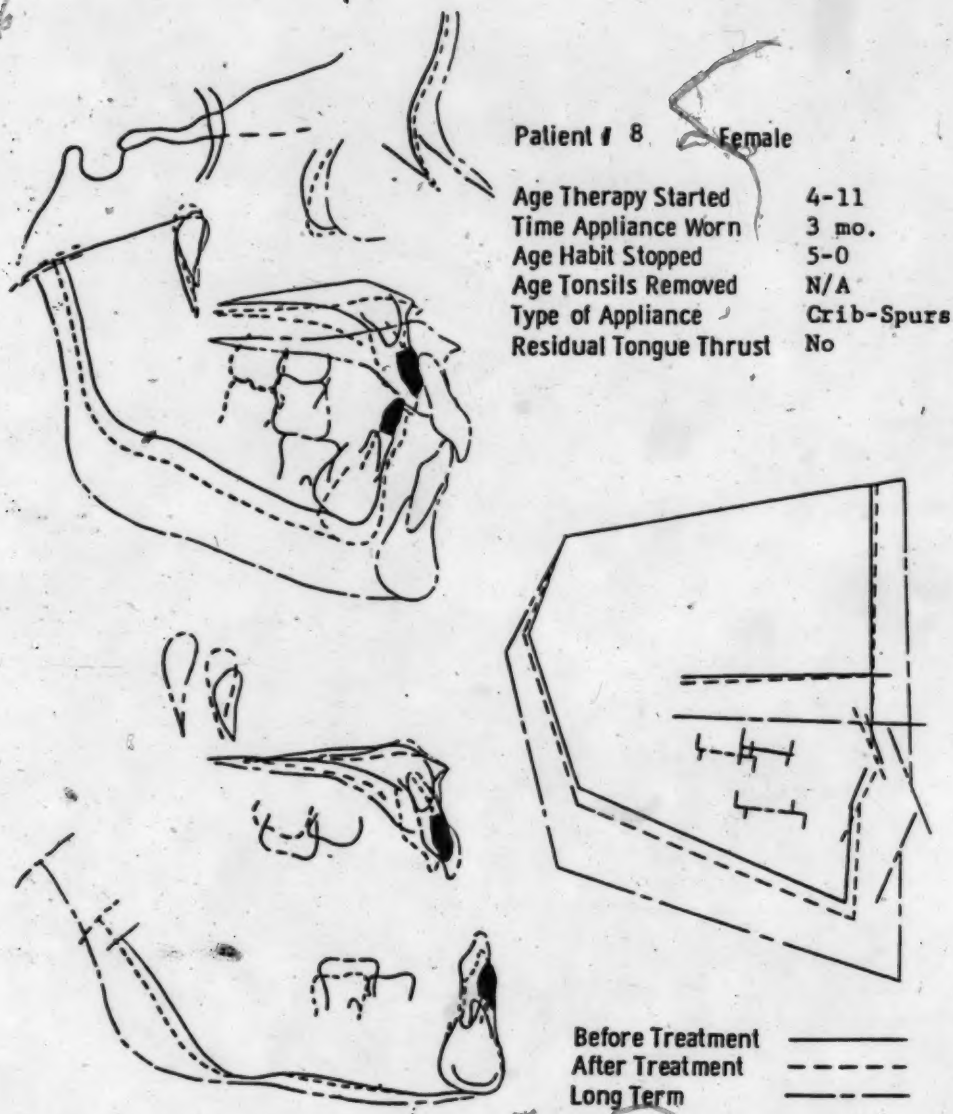
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-11	-1.5	-3.0	2.0	95.0	85.0	145.0	2.0	9.5	3.5	16.5
After Treatment	7-0	+1.5	0.0	1.0	102.5	91.0	133.0	2.0	23.0	3.5	22.5
Long Term	15-4	+5.0	0.0	2.0	101.5	93.0	136.0	3.0	20.0	4.0	22.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	4-11	81.0	77.5	3.5	9.0	19.0	35.0	54.5	89.0	41.0	48.0
After Treatment	7-0	80.0	77.5	2.5	7.5	19.0	34.0	58.0	93.0	42.0	51.0
Long Term	15-4	82.0	80.0	2.0	12.0	17.0	29.5	72.0	108.0	53.0	55.0

APPENDIX TABLE 8 PATIENT #8

APPENDIX FIGURE 8



Patient # 8 Female

Age Therapy Started	4-11
Time Appliance Worn	3 mo.
Age Habit Stopped	5-0
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No

DENTAL MEASUREMENTS

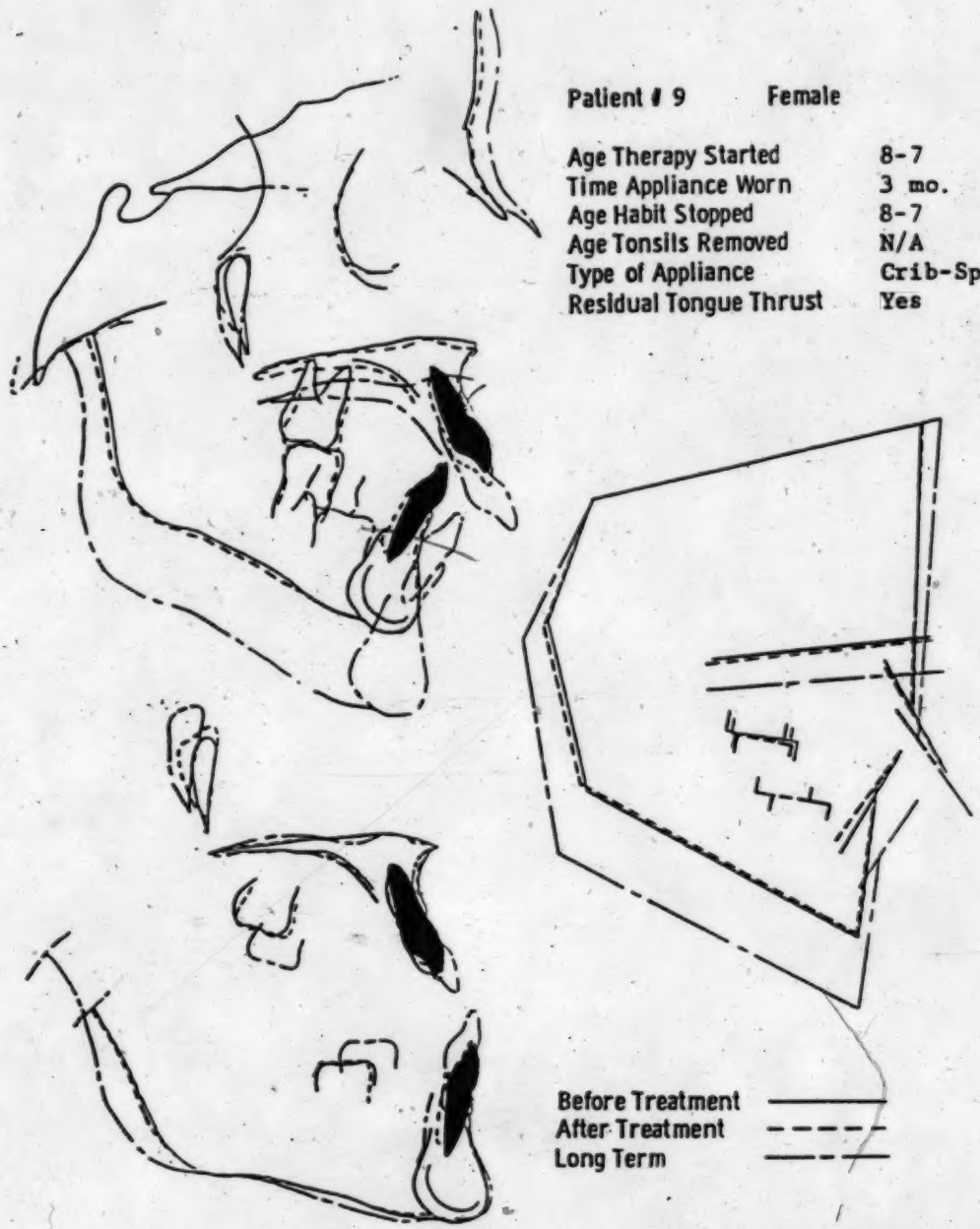
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	8-7	0.0	-3.5	9.0	104.0	89.0	123.0	6.0	28.5	4.5	23.0
After Treatment	9-7	+2.5	-2.0	9.0	105.5	95.0	116.5	7.0	31.0	4.5	27.5
Long Term	19.0	+1.5	-3.0	10.5	110.0	93.5	113.5	12.0	38.0	6.5	25.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	8-7	75.5	70.5	5.0	7.0	23.0	44.0	65.0	111.5	48.5	63.0
After Treatment	9-7	75.0	70.0	5.0	7.0	26.0	43.0	65.0	112.0	49.5	62.5
Long Term	19-0	73.0	69.5	3.5	9.0	16.5	42.0	79.0	131.0	58.0	73.0

APPENDIX TABLE 9 PATIENT #9

APPENDIX FIGURE 9



Patient # 9 Female

Age Therapy Started	8-7
Time Appliance Worn	3 mo.
Age Habit Stopped	8-7
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

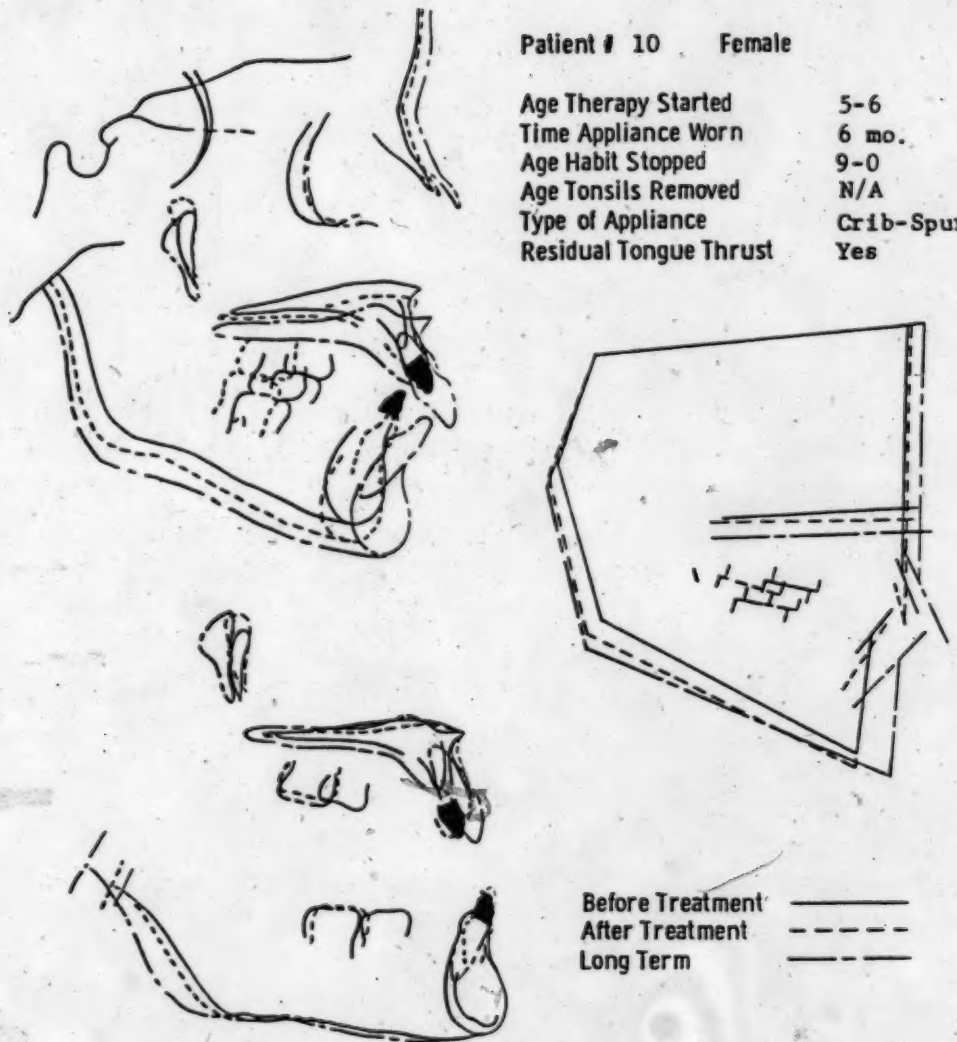
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-6	0.0	-3.0	4.0	104.0	100 0	120.5	3.5	21.0	4.0	32.5
After Treatment	6-7	-0.5	-2.0	5.0	102.0	95.0	130.5	2.0	17.5	3.0	25.5
Long Term	10-5	+2.0	-2.0	4.0	109.0	108.0	112.0	6.0	26.0	5.5	39.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	5-6	84.0	78.5	5.5	2.5	18.0	34.0	57.0	91.5	41.0	50.5
After Treatment	6-7	84.0	78.0	6.0	5.0	23.5	33.5	60.0	95.0	42.5	52.5
Long Term	10-5	83.5	80.5	3.0	4.0	17.5	29.5	60.5	97.0	45.0	52.0

APPENDIX TABLE 10 PATIENT #10

APPENDIX FIGURE 10



Patient # 10 Female

Age Therapy Started	5-6
Time Appliance Worn	6 mo.
Age Habit Stopped	9-0
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ———
After Treatment - - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

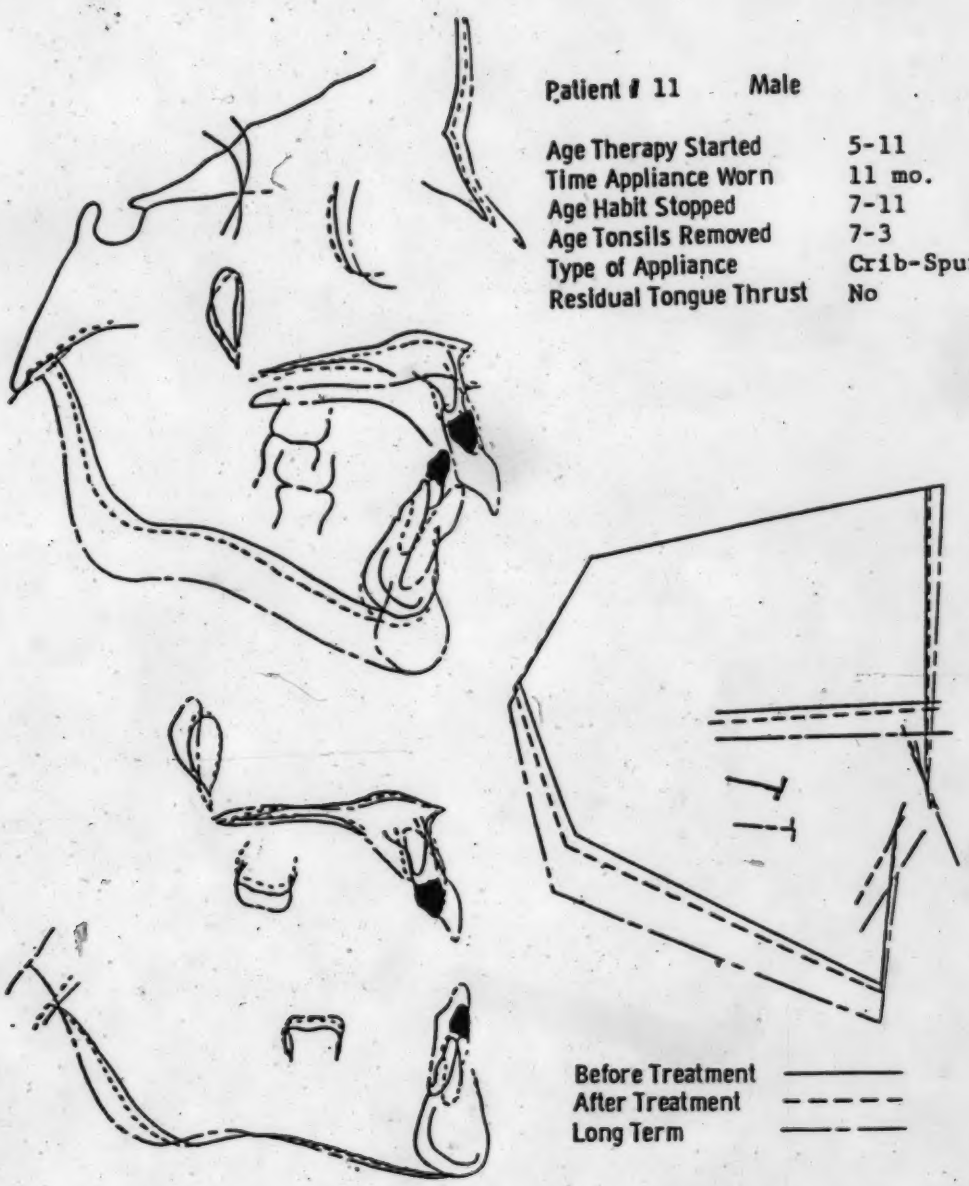
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-11	0.0	-3.0	4.0	87.0	82.0	150.0	1.5	9.0	2.0	15.5
After Treatment	6-10	-3.5	-6.5	6.0	100.0	90.0	131.5	2.0	23.0	1.5	21.0
Long Term	11-7	+6.0	0.0	7.0	99.0	97.0	127.0	7.0	24.0	5.0	24.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	5-11	78.0	73.0	5.0	9.5	24.5	40.5	59.5	105.0	47.0	58.0
After Treatment	6-10	78.0	73.0	5.0	8.5	29.0	39.0	62.0	107.5	49.0	58.5
Long Term	11-7	75.0	71.5	3.5	11.0	18.5	35.5	72.0	117.0	54.5	62.5

APPENDIX TABLE 11 PATIENT #11

APPENDIX FIGURE 11



Patient # 11 Male

Age Therapy Started	5-11
Time Appliance Worn	11 mo.
Age Habit Stopped	7-11
Age Tonsils Removed	7-3
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No

Before Treatment ——————
After Treatment - - - - -
Long Term ——— —

DENTAL MEASUREMENTS

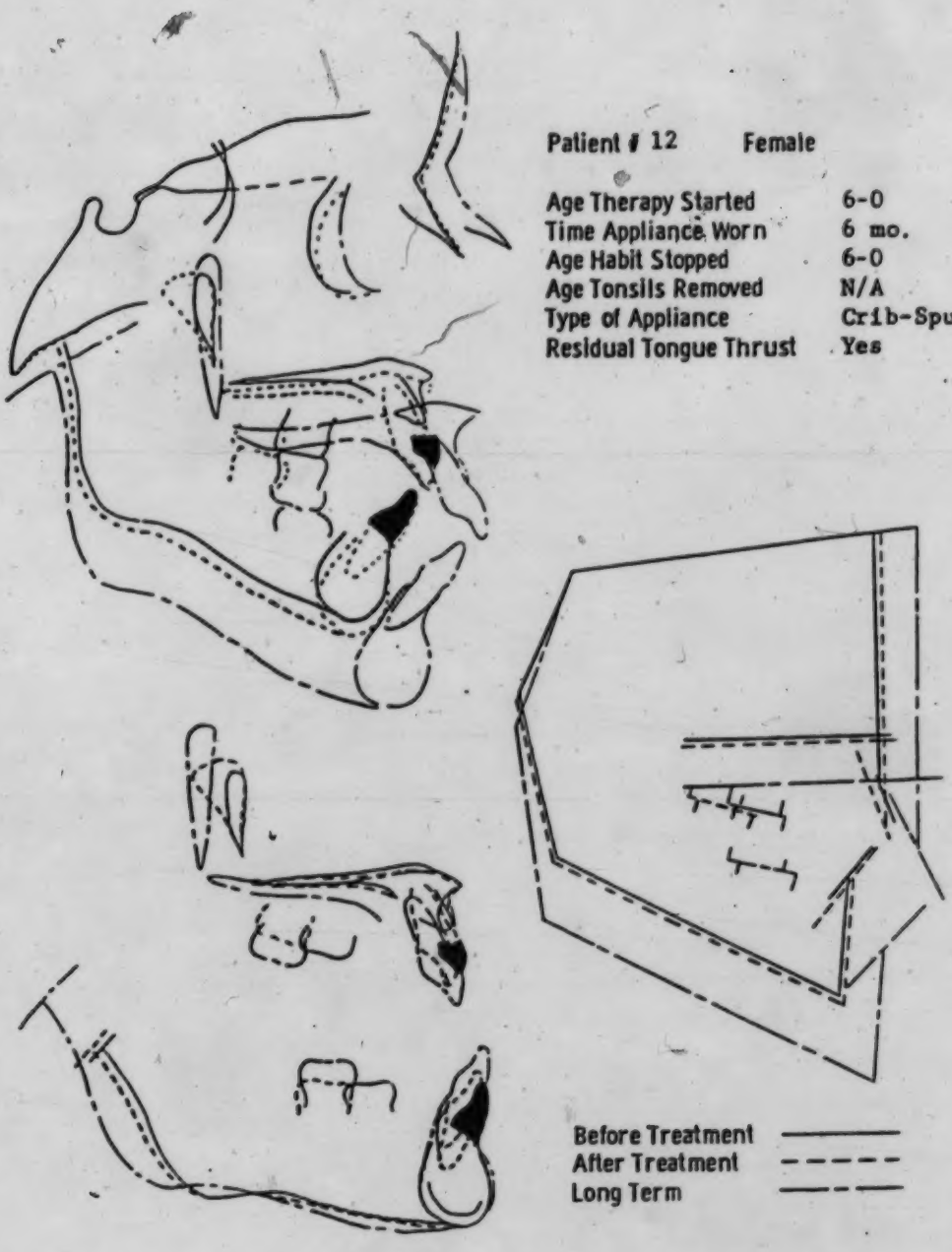
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	6-0	-6.0	-6.0	4.0	103.0	101.5	120.0	3.0	19.0	5.0	35.0
After Treatment	7-2	-2.0	-2.0	1.5	103.0	102.0	121.0	1.0	19.0	5.0	34.5
Long Term	16-4	-2.0	-3.0	4.0	108.0	104.0	112.0	5.0	25.5	8.0	39.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	6-0	85.0	79.0	6.0	5.0	21.0	35.0	62.5	98.0	44.0	54.0
After Treatment	7-2	84.0	79.0	5.0	5.5	24.5	35.0	64.0	101.5	46.0	55.5
Long Term	16-4	83.0	78.5	4.5	5.5	20.0	35.0	76.5	120.5	56.0	64.5

APPENDIX TABLE 12 PATIENT #12

APPENDIX FIGURE 12



Patient # 12 Female

Age Therapy Started	6-0
Time Appliance Worn	6 mo.
Age Habit Stopped	6-0
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term —— — ——

DENTAL MEASUREMENTS

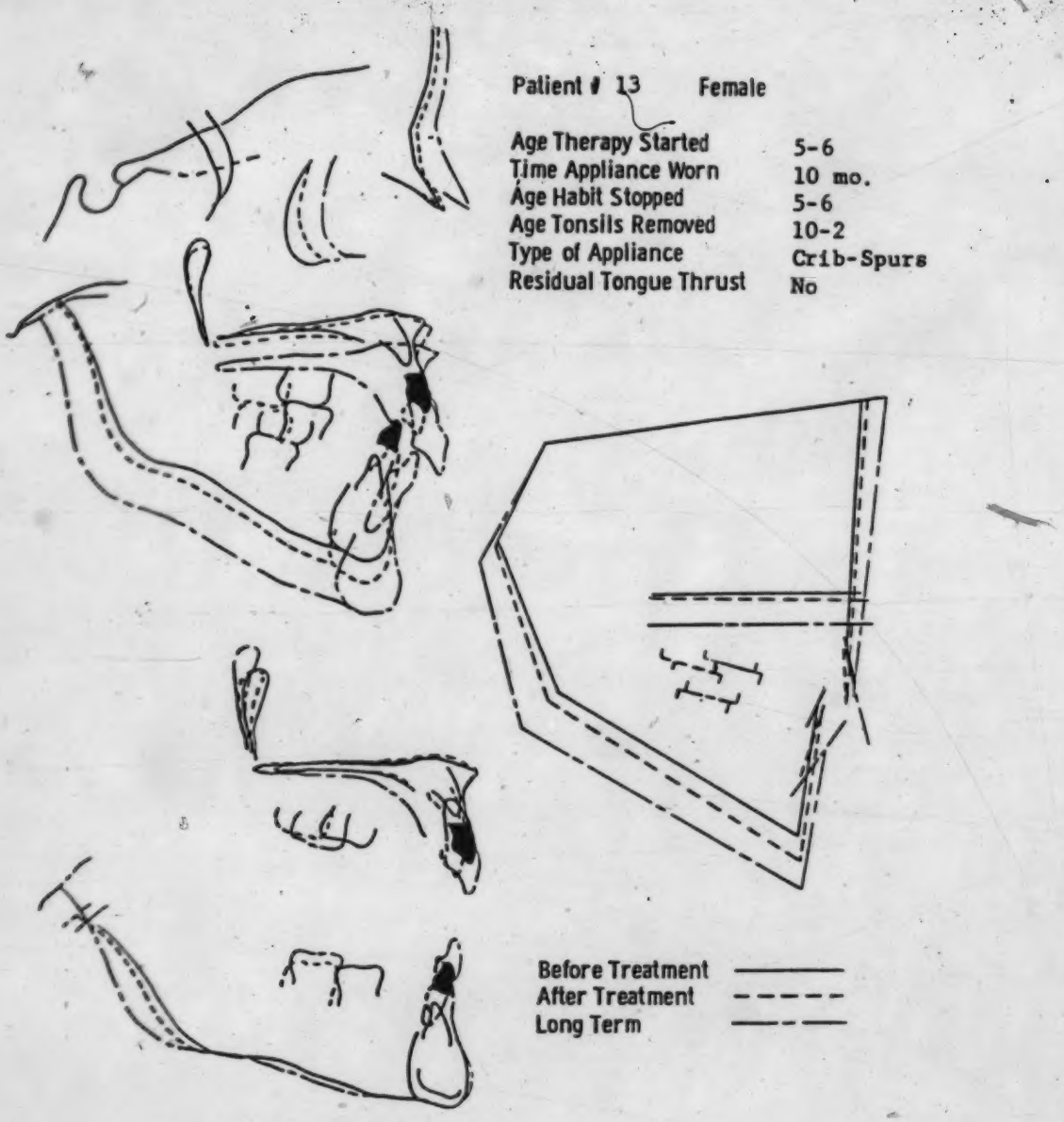
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-6	-3.5	-5.5	6.0	96.5	83.5	140.0	3.5	17.0	2.5	17.5
After Treatment	6-6	-1.5	-4.0	4.5	85.5	74.5	159.0	0.0	7.0	1.0	9.0
Long Term	12-6	+4.0	-1.0	4.5	96.0	93.5	131.0	4.5	19.5	4.0	25.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	5-6	79.5	74.5	5.0	7.0	23.0	40.0	57.5	100.0	45.0	55.0
After Treatment	6-6	78.5	74.5	4.0	8.0	25.0	41.5	59.5	106.0	47.0	59.0
Long Term	12-6	76.5	73.0	3.5	7.5	22.5	39.0	66.0	114.0	53.5	60.5

APPENDIX TABLE 13 PATIENT #13

APPENDIX FIGURE 13



Patient # 13 Female

Age Therapy Started	5-6
Time Appliance Worn	10 mo.
Age Habit Stopped	5-6
Age Tonsils Removed	10-2
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No

Before Treatment ———
After Treatment - - - -
Long Term ——— —

DENTAL MEASUREMENTS

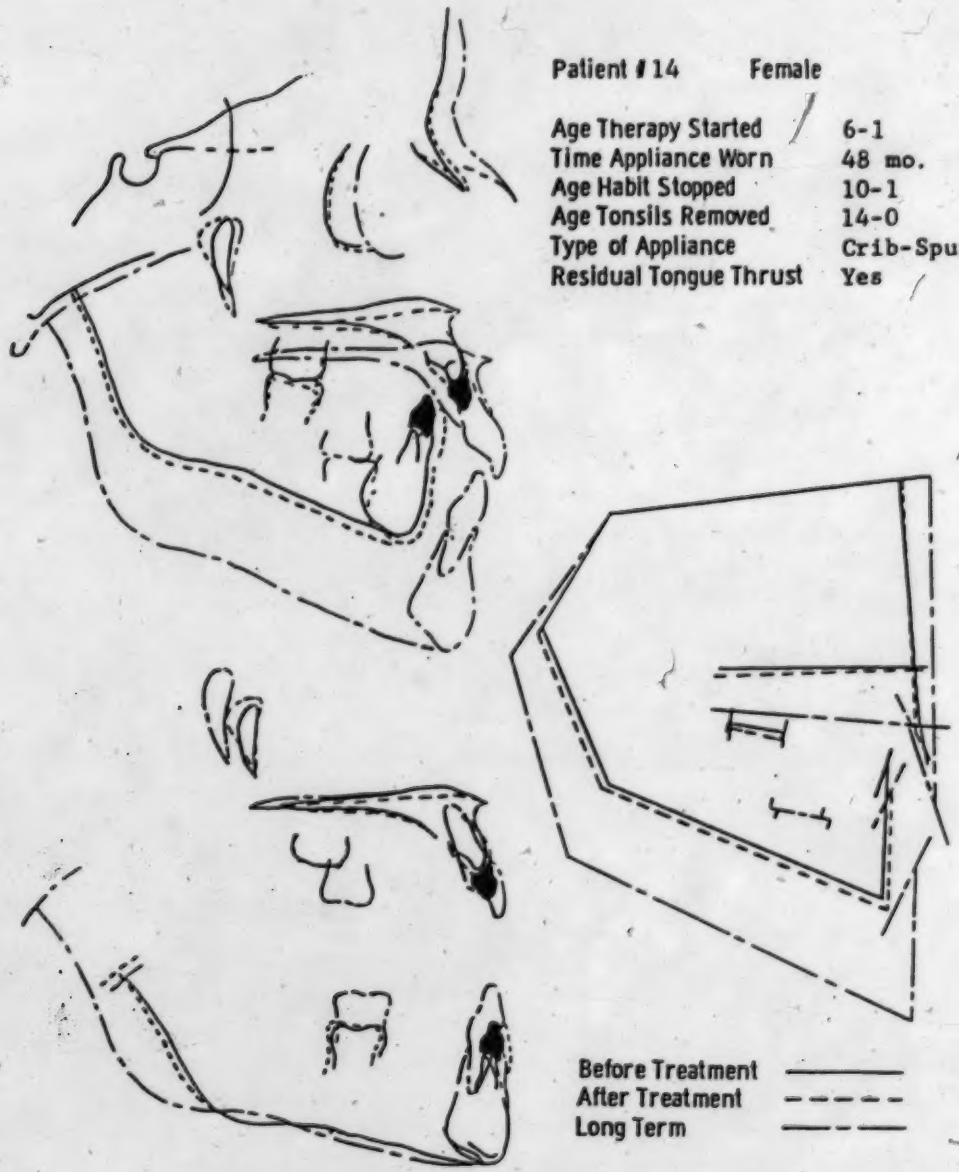
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	6-1	+2.0	-4.0	6.0	98.5	72.0	150.0	1.0	11.0	2.0	12.5
After Treatment	7-2	-2.5	-4.0	3.5	110.0	91.0	127.5	1.5	24.0	3.0	24.0
Long Term	16-5	+1.0	-3.0	2.0	100.5	88.0	137.0	2.5	11.5	3.5	23.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo. N Me		UFH	LFH
Before Treatment	6-1	87.0	81.0	6.0	6.5	17.5	31.0	58.5	89.5	41.0	48.0
After Treatment	7-2	86.0	81.0	5.0	5.5	21.0	31.5	59.5	92.0	42.5	49.5
Long Term	16-5	84.5	81.5	3.0	12.0	19.0	34.5	75.0	117.5	54.5	63.0

APPENDIX TABLE 14 PATIENT #14

APPENDIX FIGURE 14



Patient # 14 Female

Age Therapy Started	6-1
Time Appliance Worn	48 mo.
Age Habit Stopped	10-1
Age Tonsils Removed	14-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

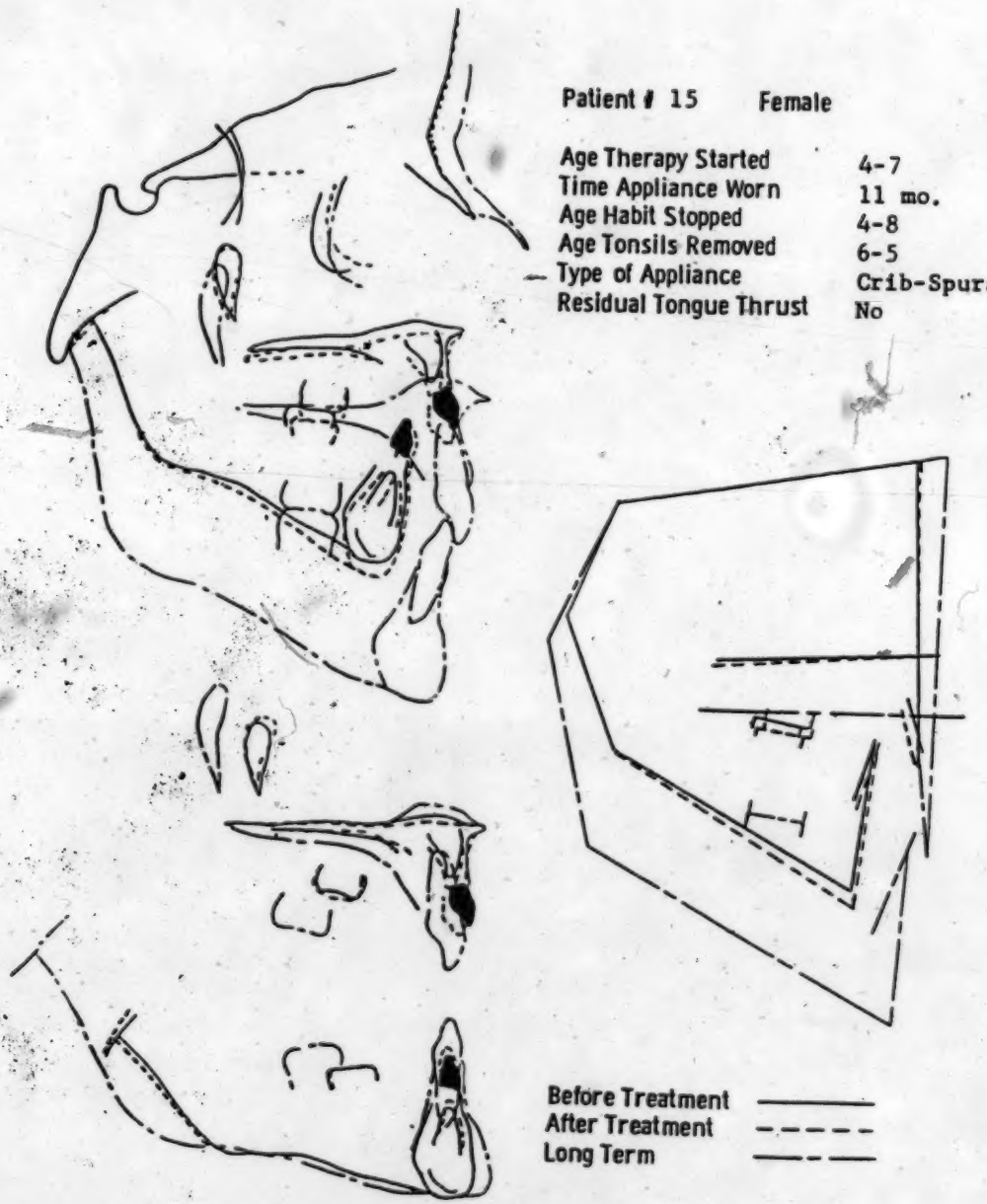
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-7	0.0	-3.5	5.0	94.5	74.0	150.0	0.5	12.0	1.0	9.0
After Treatment	5-7	+3.0	-3.0	6.0	94.0	72.0	151.5	-1.0	12.5	1.5	8.0
Long Term	14-11	+4.5	0.0	1.0	86.0	80.0	153.0	-1.0	7.5	2.5	17.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	4-7	82.0	77.0	5.0	7.0	22.0	41.5	54.5	95.5	43.5	52.0
After Treatment	5-7	81.5	74.0	7.5	5.5	20.0	43.0	55.5	97.0	44.5	52.5
Long Term	14-11	79.0	76.5	2.5	10.0	20.0	41.0	76.0	123.5	58.0	65.5

APPENDIX TABLE 15 PATIENT #15

APPENDIX FIGURE 15



Patient # 15 Female

Age Therapy Started	4-7
Time Appliance Worn	11 mo.
Age Habit Stopped	4-8
Age Tonsils Removed	6-5
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No

Before Treatment ———
After Treatment - - - -
Long Term ——— —

DENTAL MEASUREMENTS

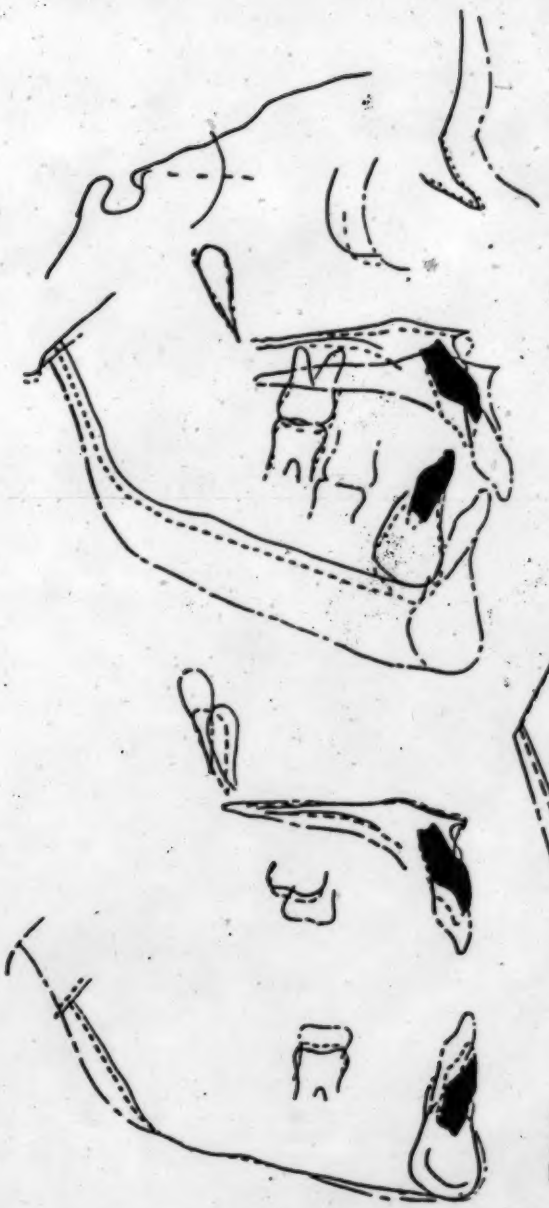
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	7-0	-7.0	-10.0	4.5	110.5	96.0	122.5	4.0	28.0	3.0	26.5
After Treatment	8-0	-1.0	-3.5	3.0	103.0	95.0	129.0	0.0	20.0	3.0	26.0
Long Term	18-4	+2.5	-2.0	3.0	98.5	94.5	132.5	2.5	17.0	4.0	26.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	7-0	83.0	79.5	3.5	7.0	18.0	31.5	63.5	98.0	42.5	55.5
After Treatment	8-0	84.0	79.0	5.0	11.0	21.0	32.5	64.5	101.5	44.5	57.0
Long Term	18-4	81.5	78.0	3.5	8.5	16.0	35.0	74.5	118.5	50.5	68.0

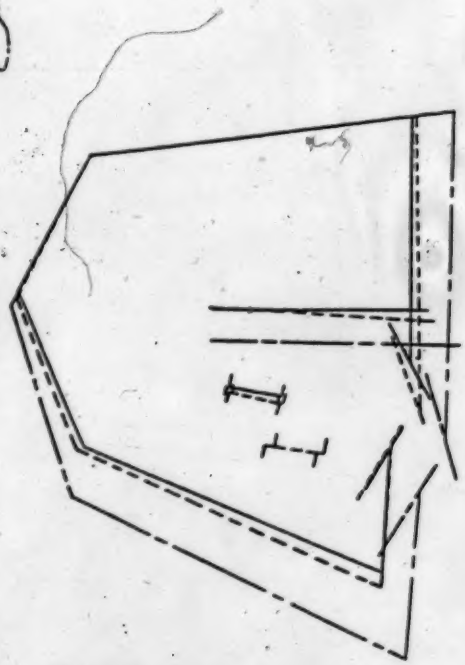
APPENDIX TABLE 16 PATIENT #16

APPENDIX FIGURE 16



Patient # 16 Female

Age Therapy Started	7-0
Time Appliance Worn	11 mo.
Age Habit Stopped	7-2
Age Tonsils Removed	5-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No



Before Treatment ——————
After Treatment - - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	9-3	+0.5	-2.5	5.0	104.0	94.5	122.5	3.5	23.0	5.0	29.0
After Treatment	10-3	+5.0	0.0	4.0	100.0	92.5	129.0	3.0	20.0	5.0	27.0
Long Term	19-7	+3.5	-0.5	3.0	106.5	90.0	131.5	6.0	25.0	4.5	22.5

SKELETAL MEASUREMENTS

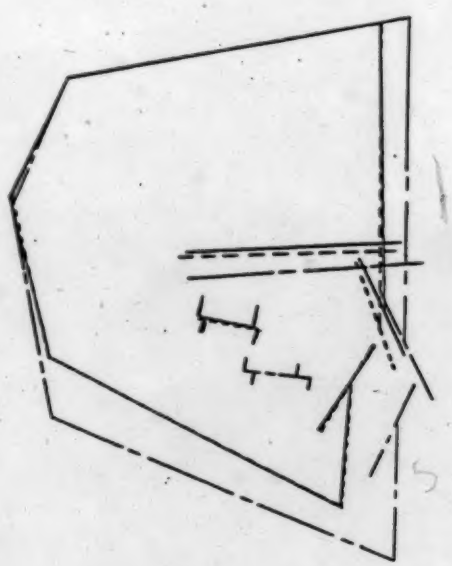
	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	9-3	81.0	75.5	5.5	7.0	25.0	39.0	61.0	104.0	48.5	55. 5
After Treatment	10-3	80.0	75.5	4.5	8.5	21.5	39.0	61.0	104.5	50.0	54.5
Long Term	19-7	81.5	80.5	1.0	6.0	16.0	32.5	74.0	115.5	51.5	64.0

APPENDIX TABLE 17 PATIENT #17

APPENDIX FIGURE 17

Patient #17 Female

Age Therapy Started	9-3
Time Appliance Worn	6 mo.
Age Habit Stopped	9-3
Age Tonsils Removed	3-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No



Before Treatment ——————
After Treatment - - - - -
Long Term ——— — ———

DENTAL MEASUREMENTS

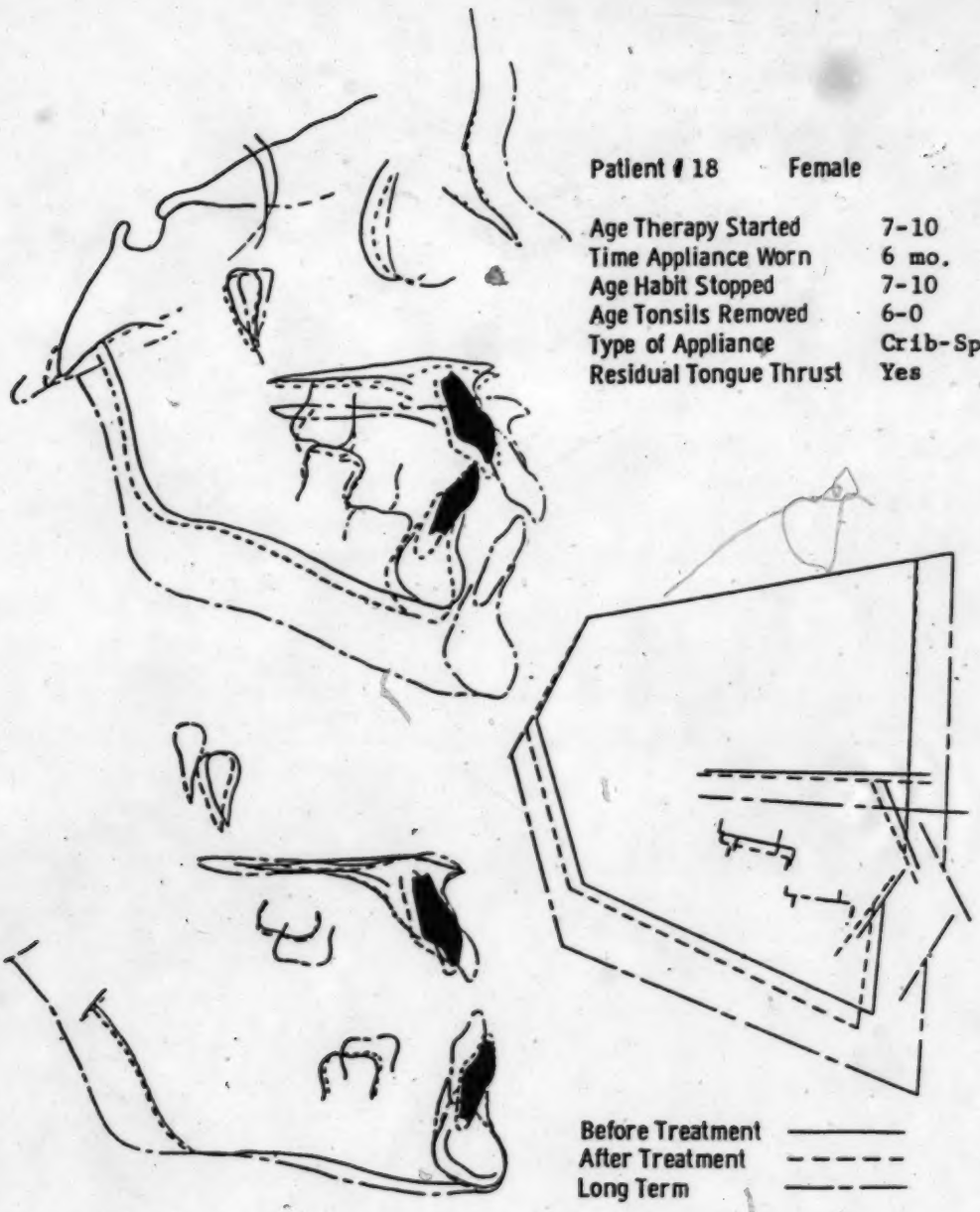
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	7-10	-1.0	-2.0	2.0	100.0	97.0	126.5	2.5	22.0	4.5	28.0
After Treatment	8-10	+0.5	-2.0	3.0	103.0	98.5	120.0	3.0	25.0	4.5	30.0
Long Term	18-0	+1.0	-2.0	2.0	103.0	99.5	123.0	5.5	25.5	5.5	29.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	7-10	78.0	75.0	3.0	12.0	23.5	36.0	59.0	100.0	48.0	52.0
After Treatment	8-10	77.5	73.0	4.5	13.0	24.5	38.0	60.0	103.5	50.0	53.5
Long Term	18-0	79.0	77.0	2.0	13.0	13.5	34.5	73.5	120.5	57.5	63.0

APPENDIX TABLE 18 PATIENT #18

APPENDIX FIGURE 18



Patient # 18 Female

Age Therapy Started	7-10
Time Appliance Worn	6 mo.
Age Habit Stopped	7-10
Age Tonsils Removed	6-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ———
After Treatment - - - - -
Long Term —— - ——

DENTAL MEASUREMENTS

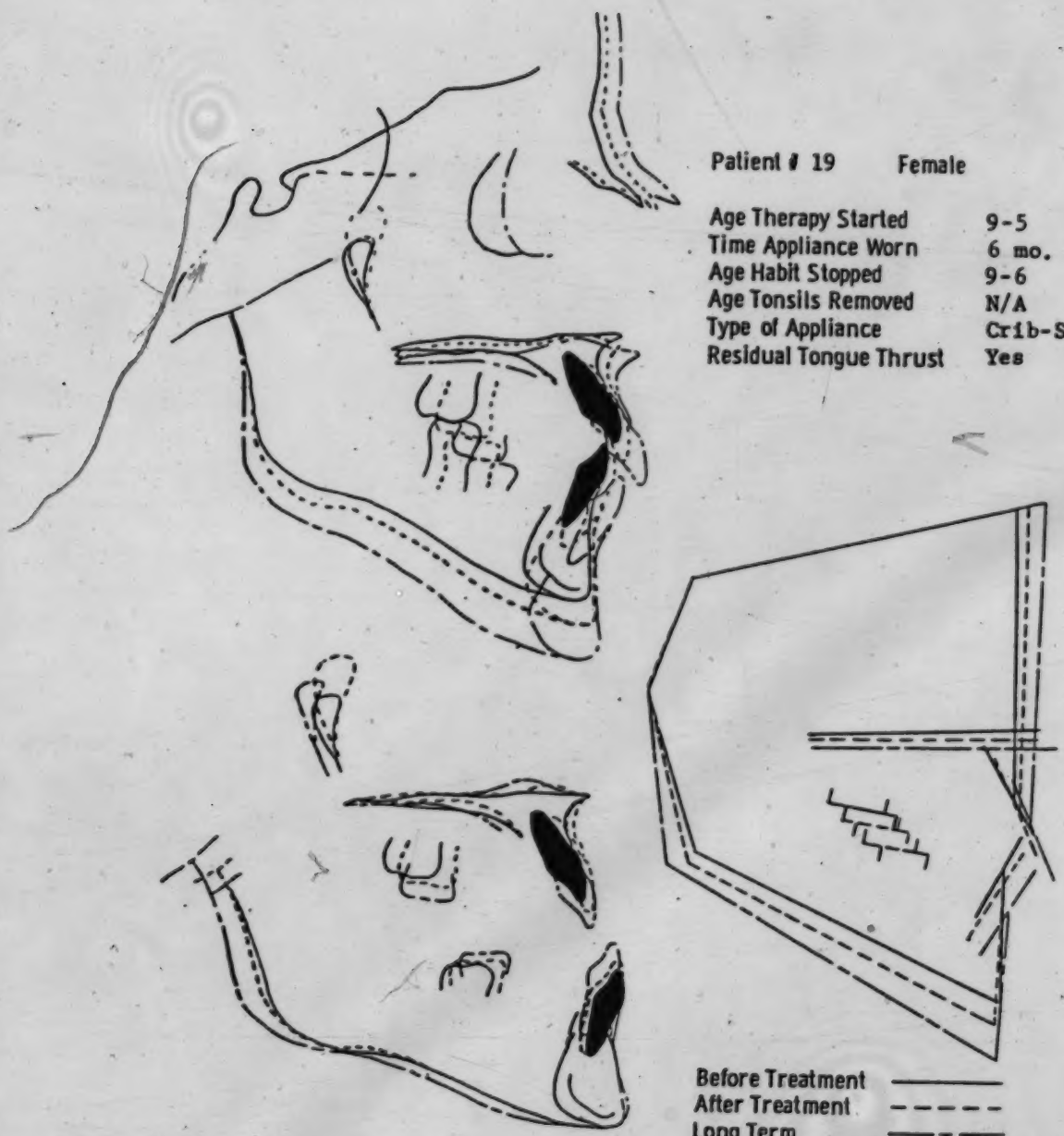
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	9-5	-0.5	-1.5	1.5	105.0	91.0	125.0	4.0	27.5	4.0	26.0
After Treatment	11-6	0.0	-1.5	1.5	99.0	92.0	127.0	3.5	23.0	5.0	28.5
Long Term	19-9	+1.5	-2.0	3.5	99.0	90.0	126.5	5.5	24.0	6.0	27.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	9-5	77.0	75.5	1.5	11.5	25.5	40.5	64.0	114.0	52.0	62.0
After Treatment	11-6	76.5	74.0	2.5	13.0	24.0	42.0	66.5	120.5	56.0	65.5
Long Term	19-9	75.0	72.5	2.5	13.5	23.5	45.0	67.0	130.0	58.0	72.0

APPENDIX TABLE 19 PATIENT #19

APPENDIX FIGURE 19



Patient # 19 Female

Age Therapy Started	9-5
Time Appliance Worn	6 mo.
Age Habit Stopped	9-6
Age Tonsils Removed	N/A
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

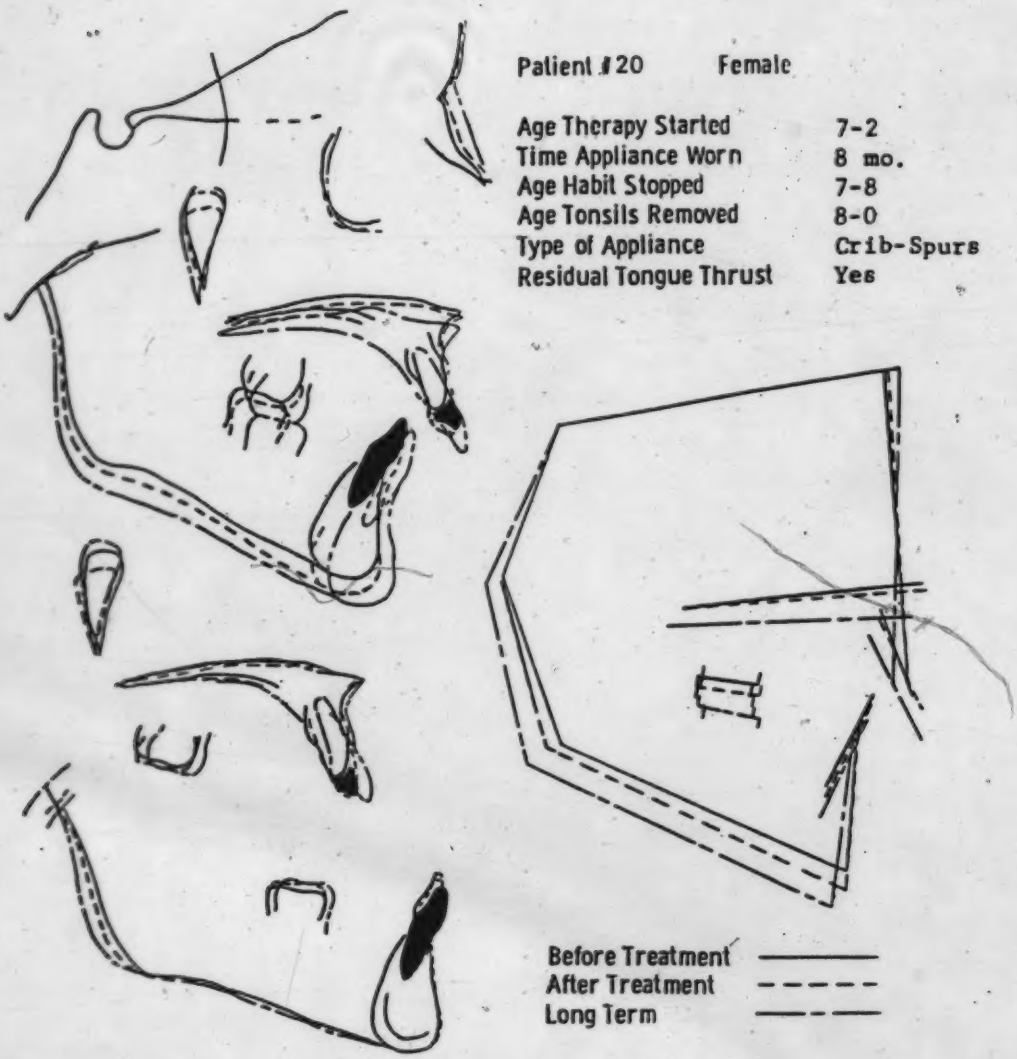
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	7-2	-0.5	-7.0	8.0	102.0	92.0	131.0	2.0	18.0	3.5	22.0
After Treatment	8-3	0.0	-7.0	8.0	104.5	89.5	130.0	3.0	21.0	3.0	21.5
Long Term	10-0	+2.0	-4.5	10.0	107.0	89.5	129.0	6.0	27.0	3.0	18.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	7-2	84.5	76.0	8.5	4.0	18.5	35.0	68.5	105.5	47.5	58.0
After Treatment	8-3	84.0	75.5	8.5	5.0	19.0	36.0	69.5	109.5	49.0	60.5
Long Term	10-0	79.0	73.0	6.0	7.0	22.0	36.0	73.0	115.0	54.5	60.5

APPENDIX TABLE 20 PATIENT #20

APPENDIX FIGURE 20



Patient #20 Female

Age Therapy Started	7-2
Time Appliance Worn	8 mo.
Age Habit Stopped	7-8
Age Tonsils Removed	8-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	Yes

Before Treatment ———
After Treatment - - - - -
Long Term ——-——

DENTAL MEASUREMENTS

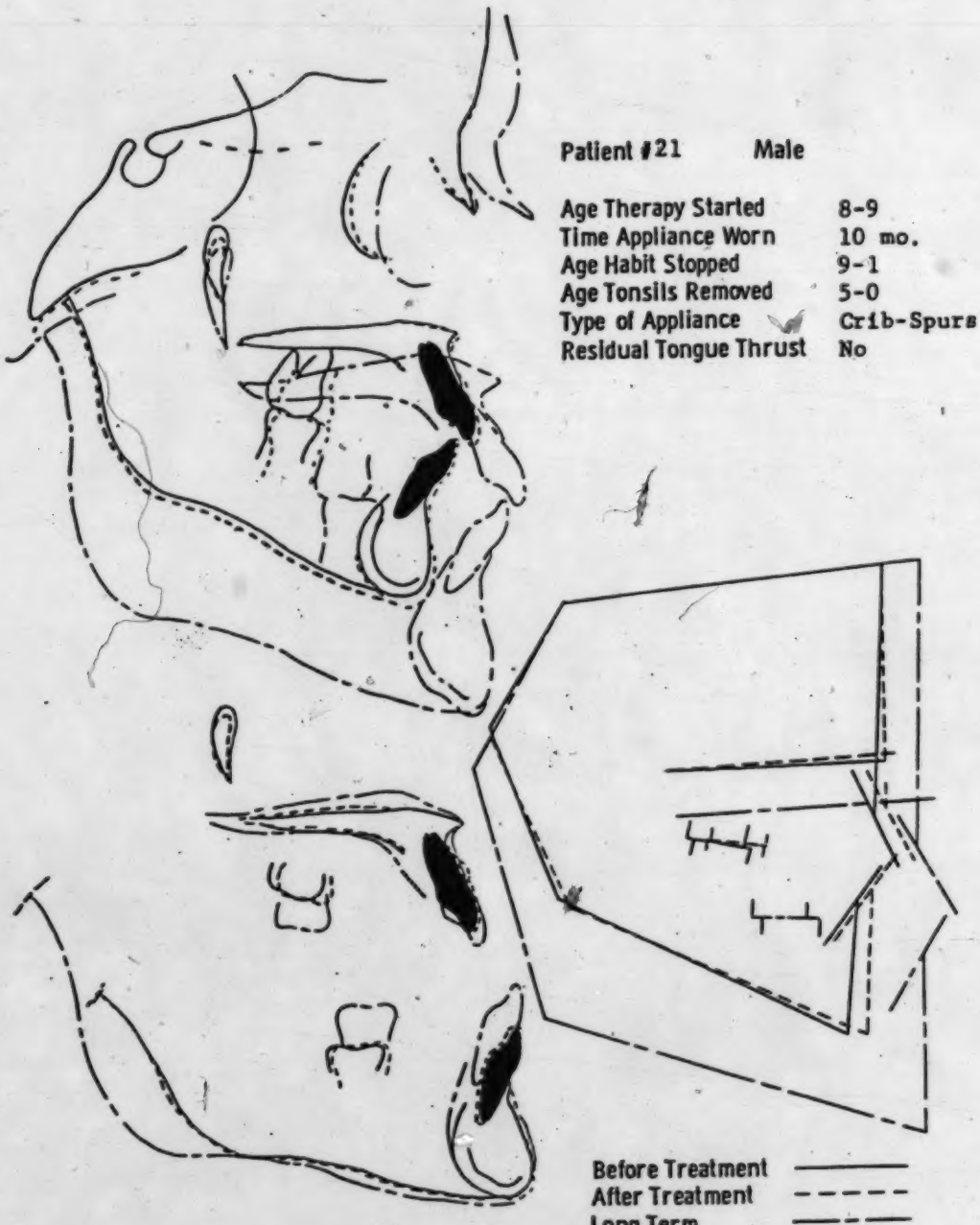
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	8-9	-0.5	-2.5	2.5	109.0	99.0	119.0	5.5	27.0	5.0	31.0
After Treatment	9-10	+1.0	-2.0	3.0	110.0	100.0	118.0	5.5	26.0	5.5	33.0
Long Term	19-2	+0.5	-1.0	1.0	112.5	101.5	121.0	9.0	30.0	5.5	30.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	8-9	81.5	79.0	2.5	4.0	18.5	33.5	68.0	105.5	45.5	60.0
After Treatment	9-10	84.0	81.0	3.0	2.5	14.0	32.0	70.0	106.0	44.0	62.0
Long Term	19-2	82.5	83.5	-1.0	3.0	8.0	25.0	95.0	129.0	55.0	74.0

APPENDIX TABLE 21 PATIENT #21

APPENDIX FIGURE 21



Patient #21 Male

Age Therapy Started	8-9
Time Appliance Worn	10 mo.
Age Habit Stopped	9-1
Age Tonsils Removed	5-0
Type of Appliance	Crib-Spurs
Residual Tongue Thrust	No

Before Treatment ——————
After Treatment - - - - -
Long Term ——— — ———

DENTAL MEASUREMENTS

	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-1	-1.5	-3.0	3.0	93.0	98.5	133.0	1.0	9.0	5.0	31.0
After Treatment	5-0	+0.5	-1.0	1.5	84.0	97.5	143.0	-1.0	0.0	4.5	31.0
Long Term	13-1	+2.0	-1.0	2.0	98.5	103.0	125.0	2.0	15.0	7.0	35.0

SKELETAL MEASUREMENTS

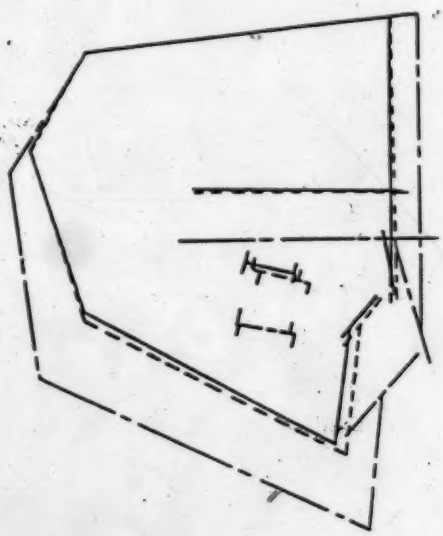
	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo	N Me	UFH	LFH
Before Treatment	4-1	84.0	76.5	7.5	7.5	22.0	36.0	56.0	90.5	38.0	52.5
After Treatment	5-0	85.0	78.0	7.0	7.0	22.0	35.0	58.5	93.0	49.0	54.0
Long Term	13-1	84.0	78.5	5.5	6.5	18.0	33.0	71.5	110.0	50.0	60.0

APPENDIX TABLE 22 PATIENT #22

APPENDIX FIGURE 22

Patient #22 Female

Age Therapy Started	4-1
Time Appliance Worn	11 mo.
Age Habit Stopped	4-2
Age Tonsils Removed	N/A
Type of Appliance	Arch
Residual Tongue Thrust	No



Before Treatment ———
After Treatment - - - - -
Long Term ——— — ———

DENTAL MEASUREMENTS

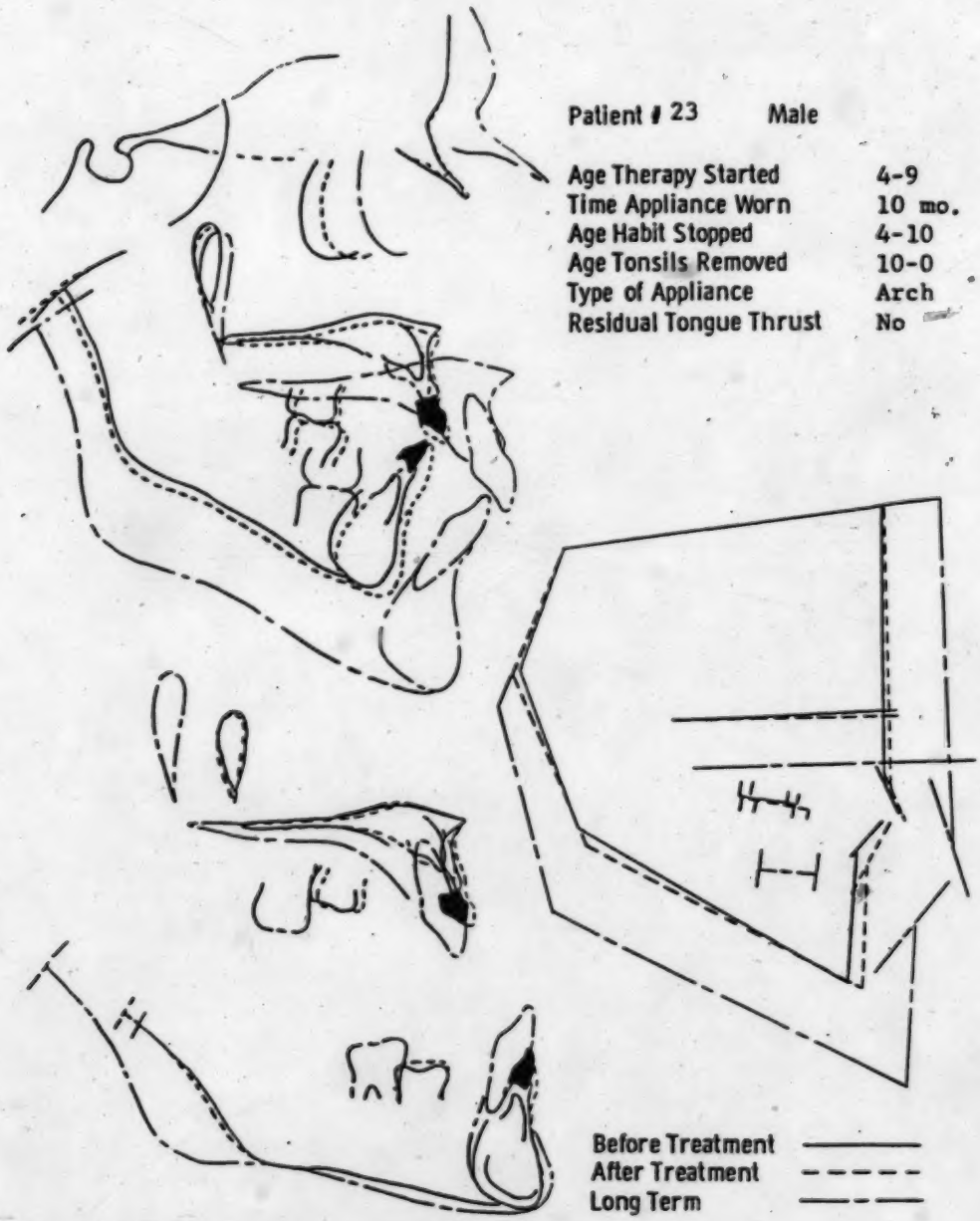
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-9	-2.0	-3.0	3.0	106.5	92.0	122.0	3.0	24.0	5.0	29.5
After Treatment	5-8	-1.0	-1.0	2.0	103.0	91.0	130.0	2.5	19.0	5.0	27.0
Long Term	16-0	+3.0	-1.0	3.0	99.5	101.0	124.0	2.5	15.0	7.0	35.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	4-9	83.0	78.5	4.5	5.0	16.0	39.5	61.0	102.0	45.0	57.0
After Treatment	5-8	84.0	80.0	4.0	6.5	18.0	36.5	65.0	103.0	46.0	57.0
Long Term	16-0	84.5	79.5	5.0	6.0	8.5	35.5	79.5	127.5	58.0	69.5

APPENDIX TABLE 23 PATIENT #23

APPENDIX FIGURE 23



DENTAL MEASUREMENTS

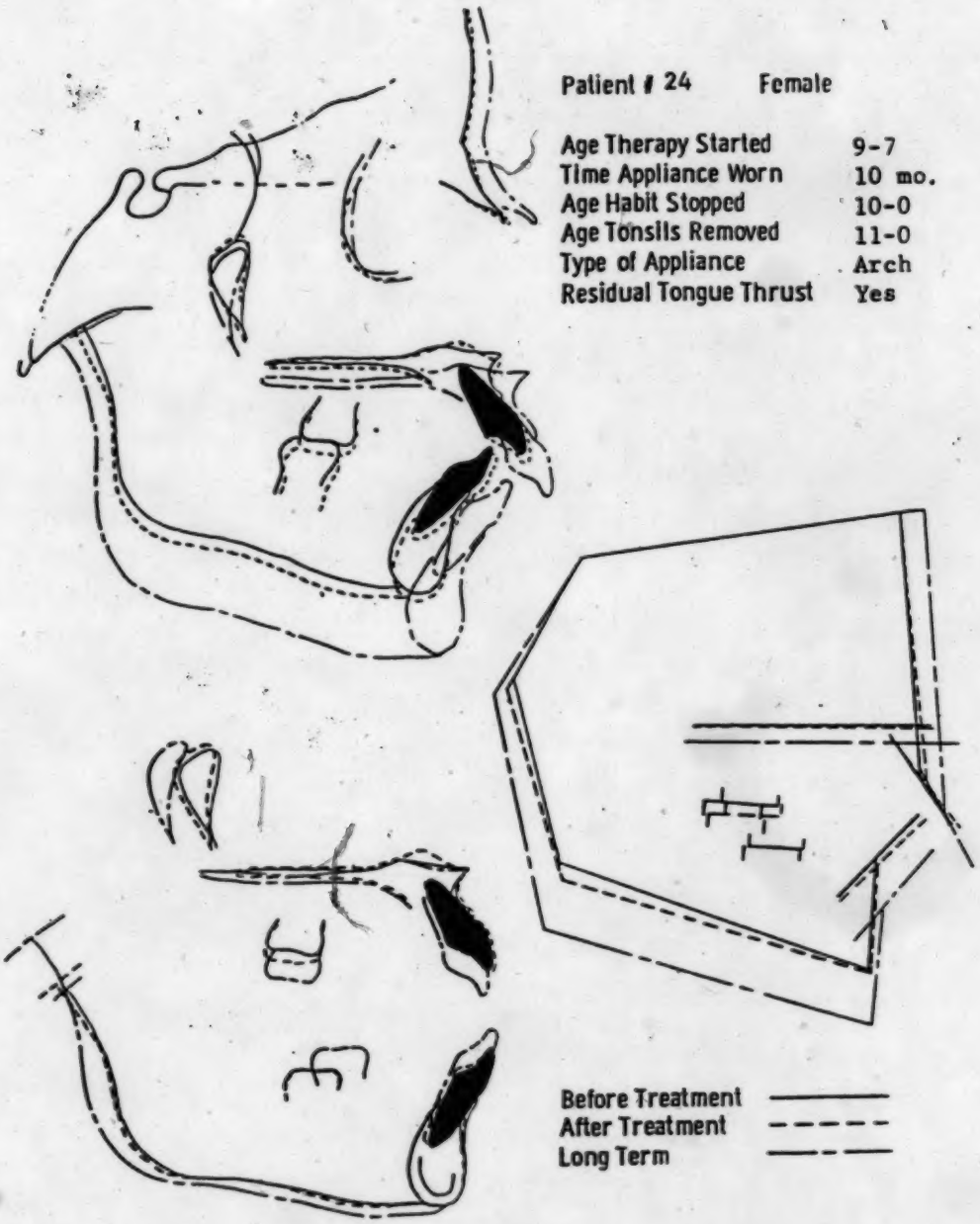
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	9-7	±2.0	-2.0	5.5	114.0	114.0	105.0	5.0	27.0	8.5	40.0
After Treatment	10-7	+2.0	-2.0	6.0	115.0	117.0	101.5	5.0	28.0	9.5	42.0
Long Term	21-1	+3.5	-2.0	8.0	109.0	112.0	113.0	5.0	23.0	10.0	34.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	9-7	86.5	78.0	8.5	8.5	13.0	28.5	68.0	99.0	47.0	52.0
After Treatment	10-7	87.5	79.0	8.5	9.0	12.0	26.0	71.0	100.5	47.5	53.0
Long Term	21-1	86.0	76.5	9.5	9.0	12.5	26.0	82.5	114.0	52.0	62.0

APPENDIX TABLE 24 PATIENT #24

APPENDIX FIGURE 24



Patient # 24 Female

Age Therapy Started	9-7
Time Appliance Worn	10 mo.
Age Habit Stopped	10-0
Age Tonsils Removed	11-0
Type of Appliance	Arch
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term —— — ——

DENTAL MEASUREMENTS

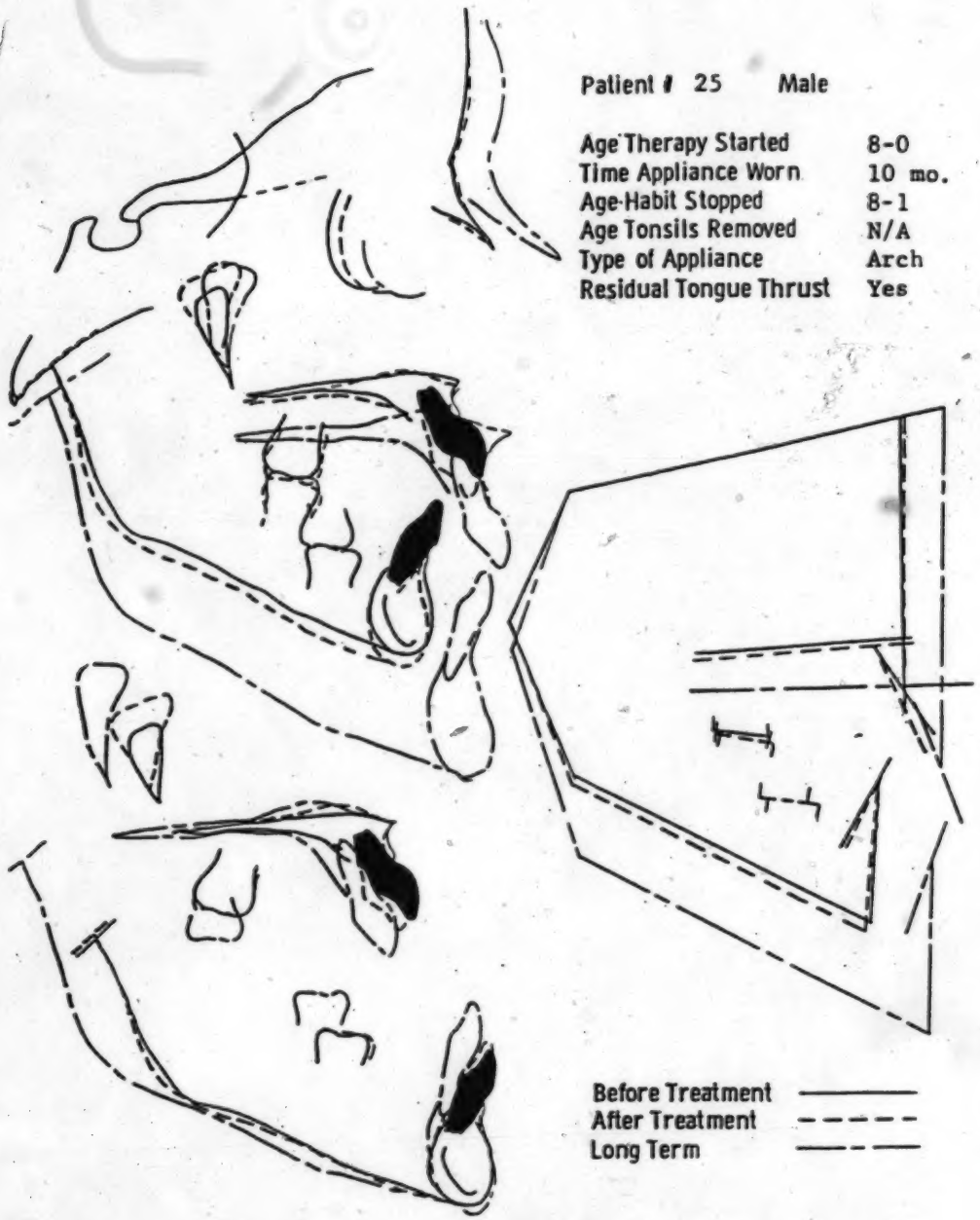
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	8-0	-6.5	-10.0	8.0	110.0	91.0	119.5	5.5	32.0	3.0	24.5
After Treatment	9-0	-3.0	-6.0	6.0	102.0	88.0	130.0	4.5	25.0	3.5	20.5
Long Term	19-4	-0.5	-1.0	2.0	98.5	84.0	139.0	4.5	22.0	4.0	18.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	8-0	78.0	74.0	4.0	9.0	20.0	40.0	62.5	109.5	49.0	60.5
After Treatment	9-0	77.0	73.0	4.0	8.0	23.0	40.0	64.5	112.0	50.5	61.5
Long Term	19-4	76.5	75.5	1.0	13.5	22.0	41.0	80.0	137.0	61.0	76.0

APPENDIX TABLE 25 PATIENT #25

APPENDIX FIGURE 25



Patient # 25 Male

Age Therapy Started	8-0
Time Appliance Worn	10 mo.
Age Habit Stopped	8-1
Age Tonsils Removed	N/A
Type of Appliance	Arch
Residual Tongue Thrust	Yes

Before Treatment ———
After Treatment - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

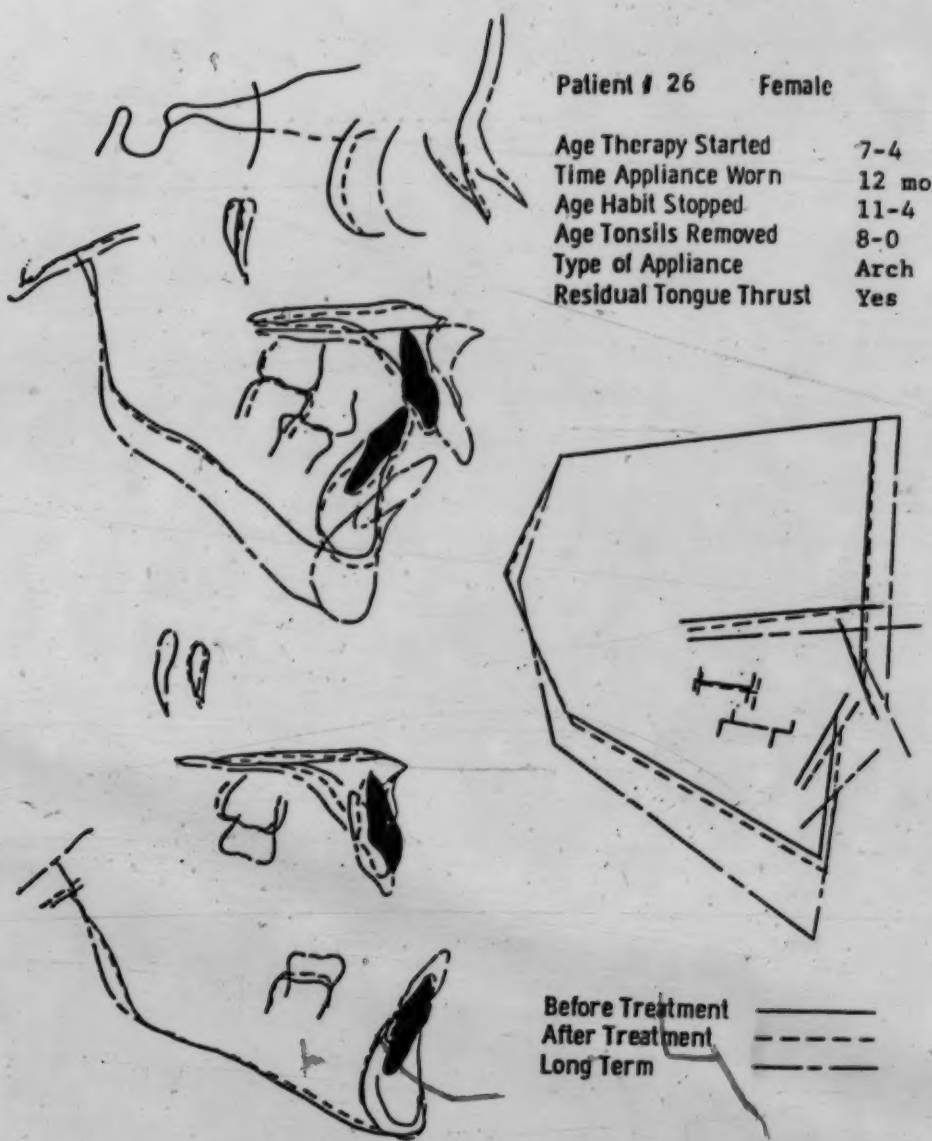
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	7-4	+3.0	-1.5	5.0	102.0	87.5	132.0	3.0	22.0	2.0	22.0
After Treatment	8-5	+3.0	-1.0	3.5	103.0	90.0	128.0	3.0	22.0	3.0	25.0
Long Term	19-3	0.0	-4.0	6.0	107.0	96.0	110.5	5.0	26.5	7.5	36.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	7-4	81.0	76.5	4.5	2.0	15.0	38.0	55.0	93.0	41.0	52.0
After Treatment	8-5	81.0	77.0	4.0	-0.5	17.0	38.0	57.5	95.0	41.5	53.5
Long Term	19-3	81.0	74.5	6.5	3.0	18.0	45.0	62.0	110.5	46.5	64.0

APPENDIX TABLE 26 PATIENT #26

APPENDIX FIGURE 26



DENTAL MEASUREMENTS

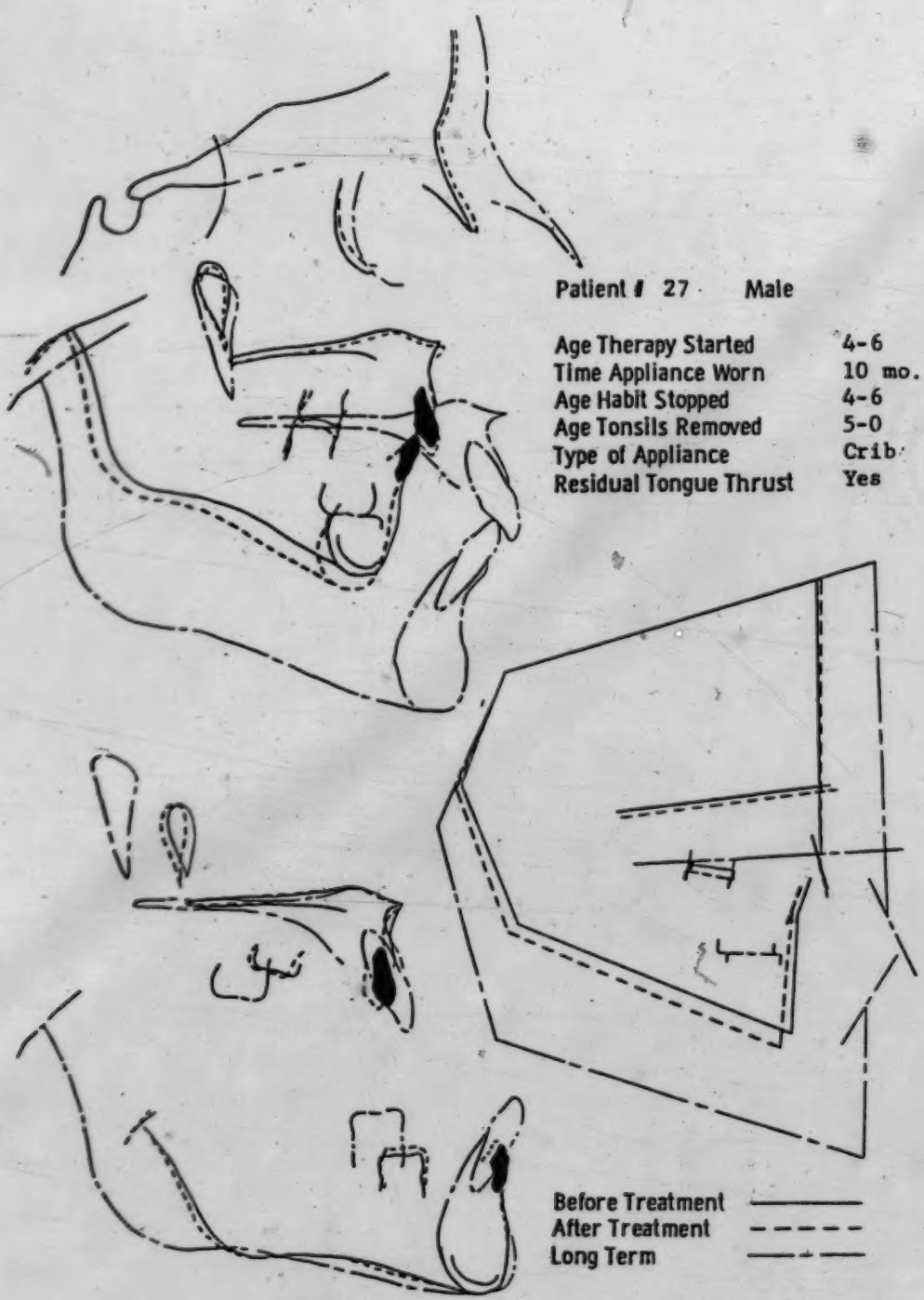
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	4-6	+2.5	-0.5	3.0	89.0	84.5	147.0	1.5	15.0	3.0	15.0
After Treatment	5-4	+1.5	-2.0	5.0	89.0	90.0	139.5	1.5	16.0	2.0	20.0
Long Term	14-8	+5.0	0.0	4.0	98.0	102.0	123.5	6.0	23.0	7.5	30.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	4-6	75.0	71.0	4.0	10.0	25.5	40.0	59.0	104.0	49.5	54.5
After Treatment	5-4	74.0	69.0	5.0	10.0	29.0	41.0	61.0	108.0	51.5	56.5
Long Term	14-8	75.0	72.0	3.0	14.0	20.0	36.0	86.0	138.0	68.0	70.0

APPENDIX TABLE 27 PATIENT #27

APPENDIX FIGURE 27



Patient # 27 Male

Age Therapy Started	4-6
Time Appliance Worn	10 mo.
Age Habit Stopped	4-6
Age Tonsils Removed	5-0
Type of Appliance	Crib
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term ——·——

DENTAL MEASUREMENTS

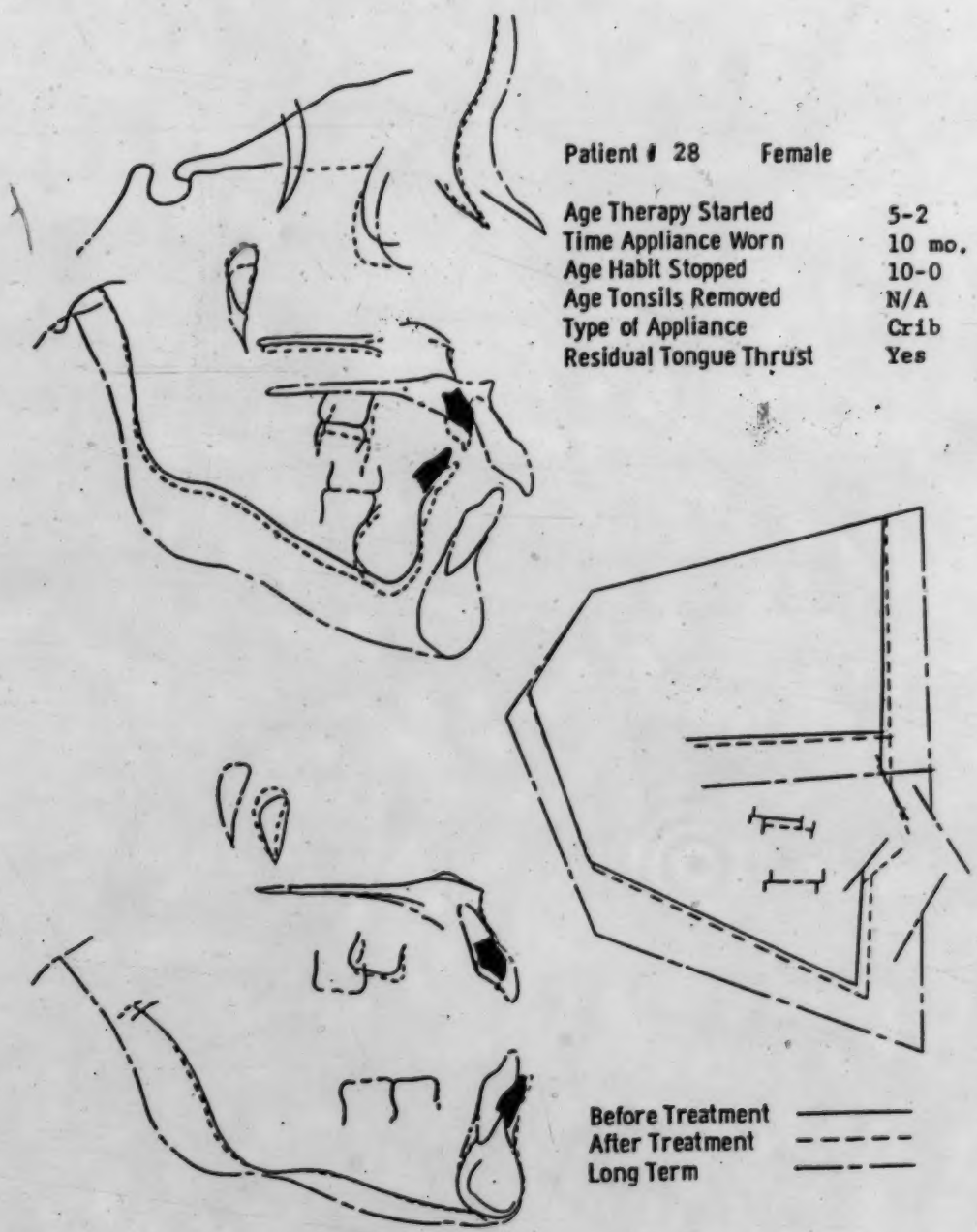
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-2	-4.0	-5.5	4.0	103.0	102.0	114.0	6.0	28.5	5.0	35.0
After Treatment	6-0	-3.0	-5.0	4.0	97.5	88.5	132.5	4.0	21.0	5.0	23.0
Long Term	15-5	+1.0	-3.0	5.0	106.0	99.0	119.0	8.5	30.0	5.5	30.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo	N Me	UFH	LFH
Before Treatment	5-2	75.0	72.0	3.0	13.0	22.0	41.5	61.0	103.5	49.0	54.5
After Treatment	6-0	76.5	73.0	3.5	12.0	21.0	41.5	62.5	106.0	50.0	56.0
Long Term	15-5	77.0	75.0	2.0	11.0	16.0	36.0	77.5	122.0	60.0	62.0

APPENDIX TABLE 28 PATIENT #28

APPENDIX FIGURE 28



Patient # 28 Female

Age Therapy Started	5-2
Time Appliance Worn	10 mo.
Age Habit Stopped	10-0
Age Tonsils Removed	N/A
Type of Appliance	Crib
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term ——— —

DENTAL MEASUREMENTS

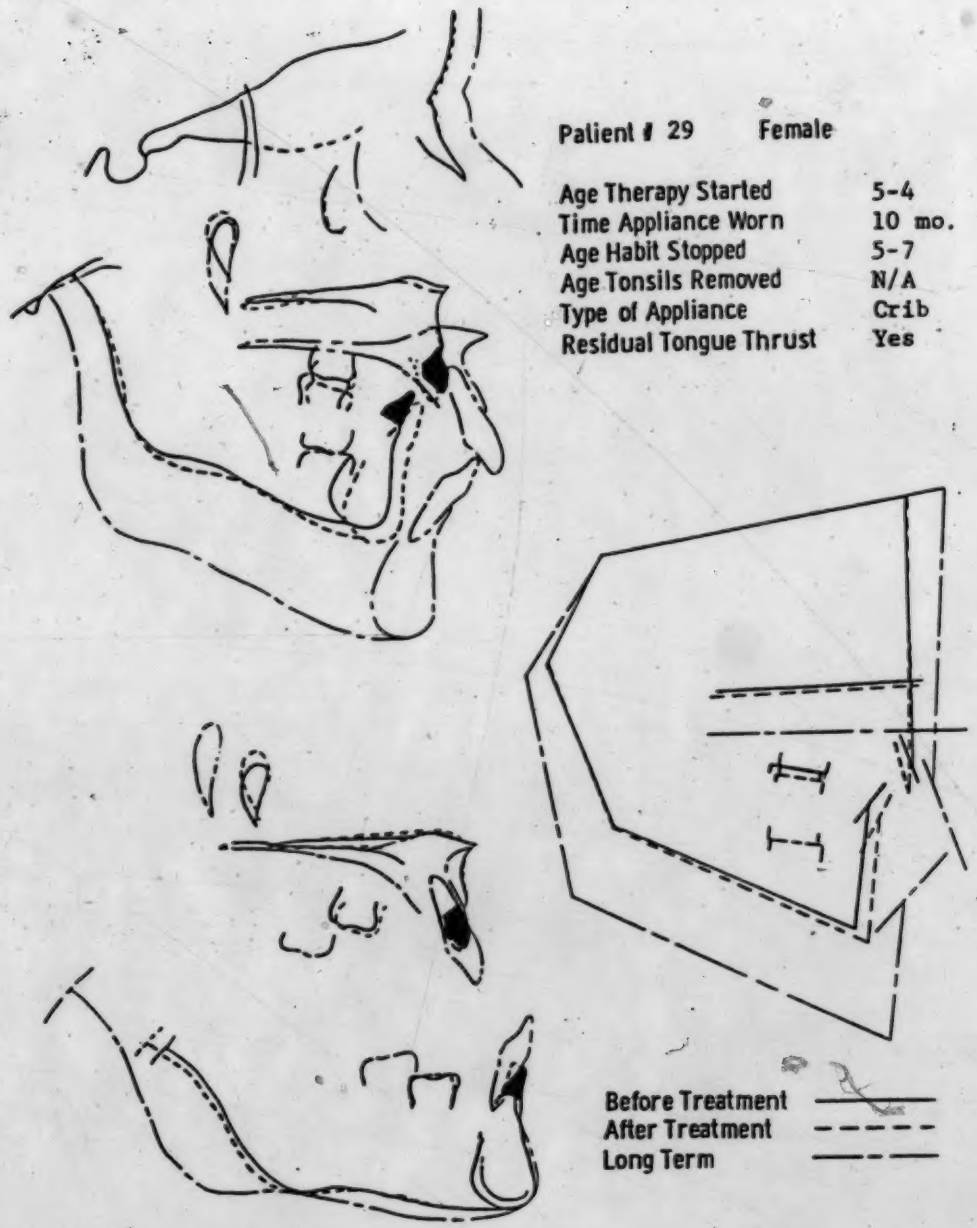
	Age	O.B. Appar.	O.B. True	O.J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-4	-1.0	-4.0	5.0	98.0	99.5	126.5	1.0	18.0	3.5	28.0
After Treatment	6-1	-3.5	-3.5	3.5	100.0	94.0	130.0	3.0	21.0	3.0	25.0
Long Term	15-6	+3.5	0.0	3.5	100.0	104.5	118.5	8.0	23.0	3.5	35.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo	N Me	UFH	LFH
Before Treatment	5-4	80.5	73.0	7.5	8.5	22.0	35.0	59.0	93.0	41.0	52.0
After Treatment	6-1	79.5	74.5	5.0	8.5	21.0	36.5	59.5	96.0	42.5	53.5
Long Term	15-6	77.0	73.5	3.5	10.5	18.5	37.5	74.0	119.0	53.0	66.0

APPENDIX FIGURE 29 PATIENT #29

APPENDIX FIGURE 29



Palient # 29 Female

Age Therapy Started	5-4
Time Appliance Worn	10 mo.
Age Habit Stopped	5-7
Age Tonsils Removed	N/A
Type of Appliance	Crib
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term ——— — ———

DENTAL MEASUREMENTS

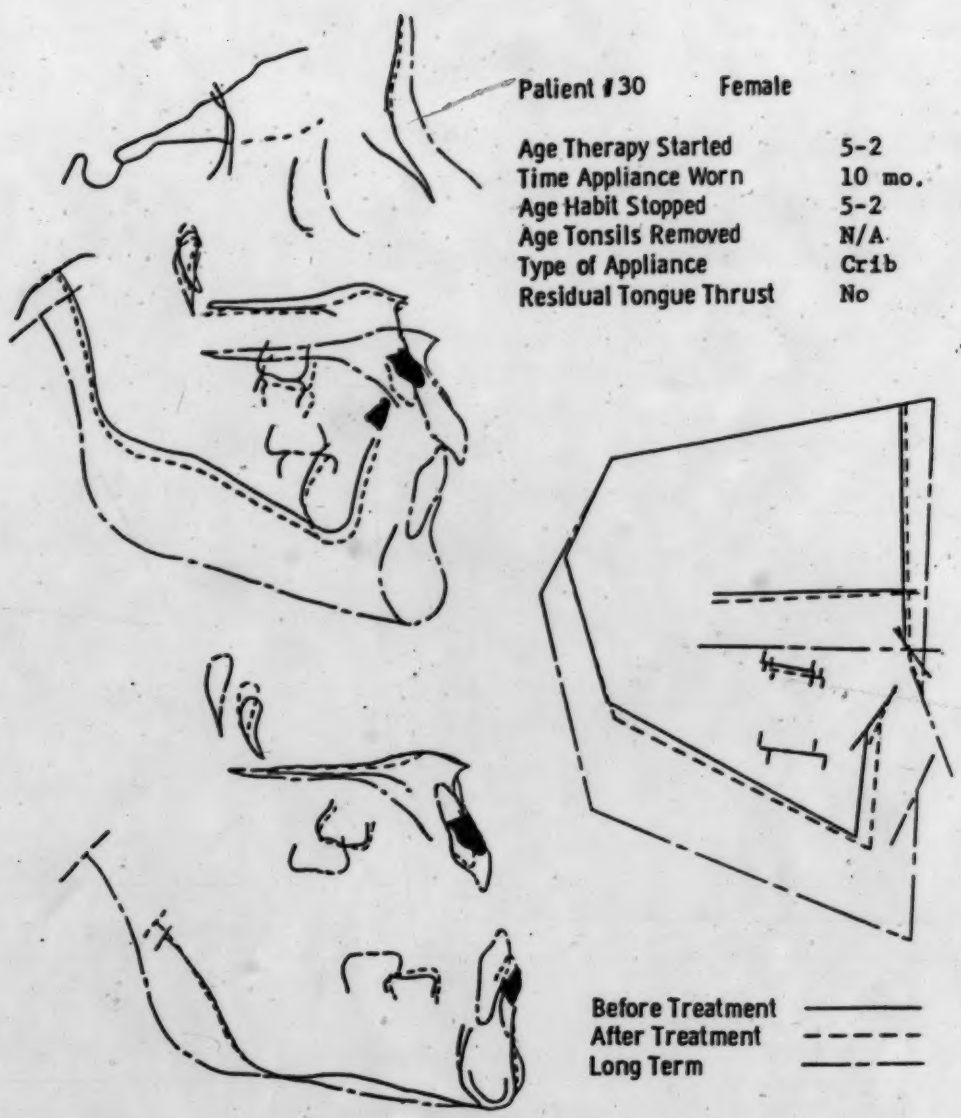
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	5-2	-3.5	-5.5	6.0	115.0	96.0	109.0	5.5	35.0	5.5	30.0
After Treatment	5-11	+1.0	-2.5	4.5	98.0	86.5	135.5	3.0	18.5	3.5	20.0
Long Term	15-4	+4.5	-0.5	3.0	100.0	91.0	135.0	7.0	22.0	4.0	22.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	5-2	80.5	74.0	6.5	10.0	22.0	40.5	53.0	91.5	40.5	51.0
After Treatment	5-11	80.0	75.0	5.0	8.5	21.0	39.0	56.5	94.5	42.5	52.0
Long Term	15-4	77.5	77.0	0.5	12.0	18.0	35.0	76.5	116.0	54.0	62.0

APPENDIX TABLE 30 PATIENT #30

APPENDIX FIGURE 30



Patient #30 Female

Age Therapy Started	5-2
Time Appliance Worn	10 mo.
Age Habit Stopped	5-2
Age Tonsils Removed	N/A
Type of Appliance	Crib
Residual Tongue Thrust	No

Before Treatment ———
After Treatment - - - -
Long Term —— - ——

DENTAL MEASUREMENTS

	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	9-2	0.0	-4.0	5.5	111.0	92.0	121.5	7.0	30.0	3.5	21.5
After Treatment	9-11	+1.0	-2.0	6.0	109.0	89.0	127.5	7.0	29.0	2.5	22.0
Long Term	19-4	+4.0	-0.5	2.0	100.5	94.0	132.5	4.5	20.0	4.0	27.0

SKELETAL MEASUREMENTS

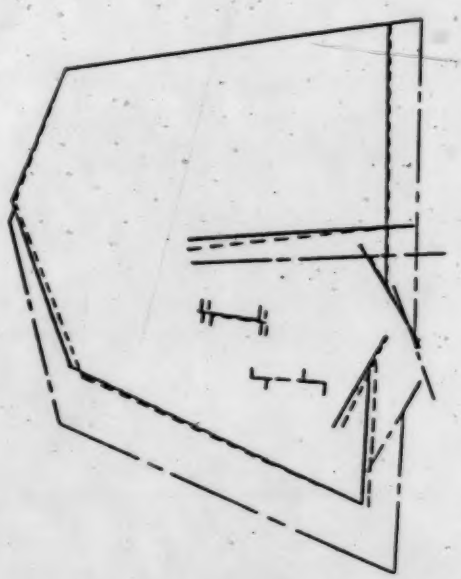
	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me		UFH	LFH
Before Treatment	9-2	81.0	79.0	2.0	5.0	17.5	35.0	65.0	103.5	45.0	58.5
After Treatment	9-11	81.0	79.0	2,0	2.5	19.0	34.0	67.5	104.5	45.5	59.0
Long Term	19-4	81.0	80.0	1.0	6.0	12.0	33.5	78.0	120.5	51.5	69.0

APPENDIX TABLE 31 PATIENT #31

APPENDIX FIGURE 31

Patient # 31 Female

Age Therapy Started	9-2
Time Appliance Worn	10 mo.
Age Habit Stopped	9-2
Age Tonsils Removed	6-0
Type of Appliance	Crib
Residual Tongue Thrust	No



Before Treatment ———
After Treatment - - - - -
Long Term ——— - ———

DENTAL MEASUREMENTS

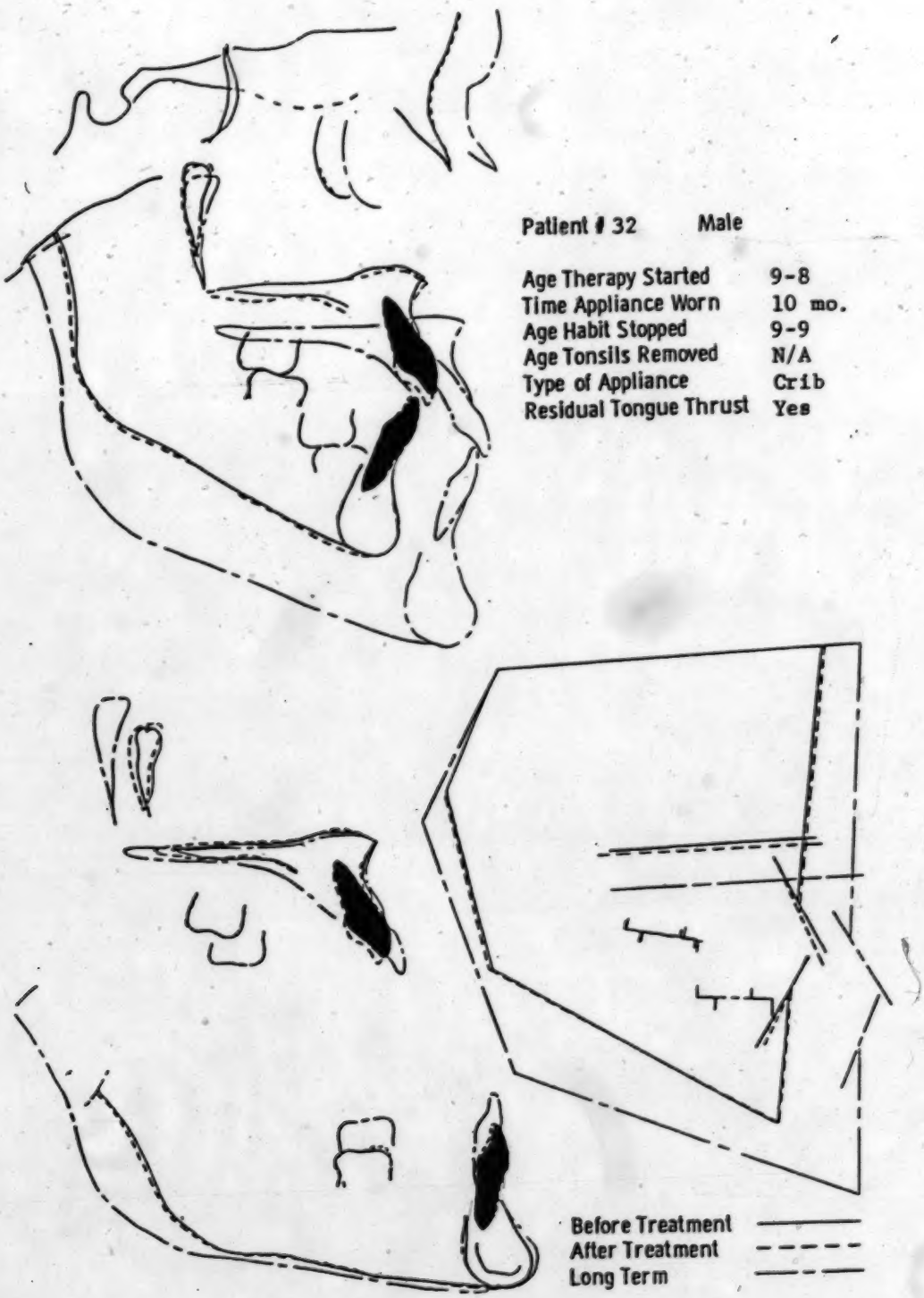
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	9-8	-1.5	-3.0	3.0	112.5	89.0	124.0	7.5	32.0	4.5	24.5
After Treatment	10-6	+2.0	-1.5	2.5	109.0	86.0	131.0	7.0	29.0	4.0	20.5
Long Term	19-11	+2.5	0.0	2.0	117.0	89.5	128.0	10.5	33.0	5.5	21.0

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo-N Me		UFH	LFH
Before Treatment	9-8	80.5	80.5	0.0	1.0	13.5	34.0	73.0	114.5	47.5	67.0
After Treatment	10-6	80.5	80.0	+0.5	1.5	14.0	34.0	73.0	115.5	49.0	66.5
Long Term	19-11	84.0	86.0	-2.0	1.0	6.0	26.5	96.5	135.0	57.5	77.5

APPENDIX TABLE 32 PATIENT #32

APPENDIX FIGURE 32



Patient # 32 Male

Age Therapy Started	9-8
Time Appliance Worn	10 mo.
Age Habit Stopped	9-9
Age Tonsils Removed	N/A
Type of Appliance	Crib
Residual Tongue Thrust	Yes

Before Treatment
After Treatment
Long Term

DENTAL MEASUREMENTS

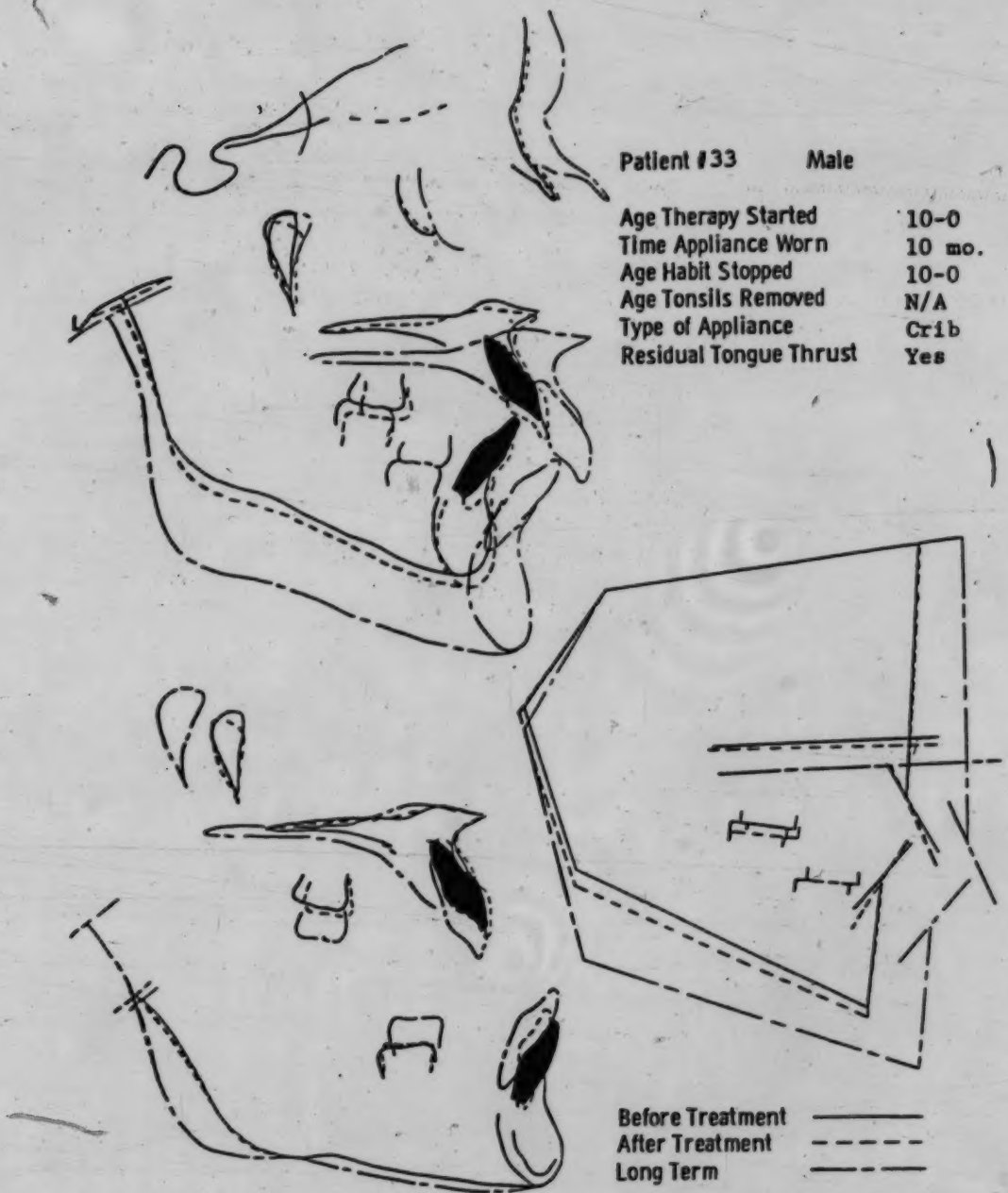
	Age	O. B. Appar.	O. B. True	O. J.	$\underline{1}$-SN	$\bar{1}$-MP	$\underline{1}$-$\bar{1}$	$\underline{1}$-NA (mm)	$\underline{1}$-NA (deg)	$\bar{1}$-NB (mm)	$\bar{1}$-NB (deg)
Before Treatment	10-0	+1.5	-2.5	5.0	111.0	103.5	110.0	8.0	32.0	7.0	35.0
After Treatment	10-10	+5.0	-0.5	6.0	105.0	96.5	123.5	7.5	26.5	5.0	26.0
Long Term	20-3	+5.5	-0.5	6.0	106.0	111.0	115.0	6.0	23.5	8.0	35.5

SKELETAL MEASUREMENTS

	Age	SNA	SNB	ANB	Pal. Pl. SN	Occl. SN	MP-SN	SGo N Me	UFH	LFH
Before Treatment	10-0	79.0	75.5	3.5	6.0	16.5	35.0	65.0	106.0	45.5	60.5
After Treatment	10-10	79.0	76.0	3.0	7.5	15.5	34.0	69.0	108.5	47.0	61.5
Long Term	20-3	83.0	77.5	5.5	6.0	14.0	28.0	86.0	124.0	53.0	71.0

APPENDIX TABLE 33 PATIENT #33

APPENDIX FIGURE 33



Patient #33 Male

Age Therapy Started	10-0
Time Appliance Worn	10 mo.
Age Habit Stopped	10-0
Age Tonsils Removed	N/A
Type of Appliance	Crib
Residual Tongue Thrust	Yes

Before Treatment ——————
After Treatment - - - - -
Long Term —— - ——

APPENDIX TABLE 34

Correlation of Apparent Overbite (OBA) and Other Cephalometric Measurements

Cephalometric Measurements	Before Treatment and After Treatment	After Treatment and Long Term	Before Treatment and Long Term
$\underline{1}$-SN (°)	-0.5594 P<0.001	-0.0976 P<0.295	0.2769 P<0.059
$\overline{1}$-MP (°)	-0.3004 P<0.045	0.4064 P<0.009	-0.0861 P<0.317
$\underline{1}$-$\overline{1}$ (°)	0.4739 P<0.003	-0.0879 P<0.313	0.3565 P<0.021
$\underline{1}$-NA (mm)	-0.3707 P<0.017	0.2429 P<0.087	-0.0929 P<0.303
$\underline{1}$-NA (°)	-0.5790 P<0.001	-0.1091 P<0.273	-0.2567 P<0.075
$\overline{1}$-NB (mm)	-0.0703 P<0.349	0.0193 P<0.458	-0.3149 P<0.037
$\overline{1}$-NB (°)	-0.2131 P<0.117	0.2448 P<0.085	-0.2268 P<0.102
SNA (°)	-0.1262 P<0.242	-0.2472 P<0.083	-0.1020 P<0.286
SNB (°)	-0.1165 P<0.259	-0.1908 P<0.144	0.0637 P<0.362
ANB (°)	-0.0426 P<0.407	-0.0905 P<0.308	-0.2167 P<0.113
Pal.Pl-SN (°)	0.1700 P<0.172	0.1498 P<0.203	-0.0294 P<0.436
Occl.Pl.-SN (°)	-0.2916 P<0.050	-0.2690 P<0.065	-0.2796 P<0.058
MP-SN (°)	0.2196 P<0.110	-0.1059 P<0.279	-0.2570 P<0.074
N Me (mm)	-0.2214 P<0.108	0.0833 P<0.322	0.1796 P<0.159
UFH (mm)	0.0332 P<0.427	0.2988 P<0.046	0.2923 P<0.049
LFH (mm)	-0.1299 P<0.236	-0.0063 P<0.486	0.0331 P<0.427

APPENDIX TABLE 35

Correlation of True Overbite (OBT) and Other Cephalometric Measurements

Cephalometric Measurements	Before Treatment and After Treatment	After Treatment and Long Term	Before Treatment and Long Term
$\underline{1}$-SN (°)	-0.4796 P<0.002	-0.0969 P<0.296	-0.3717 P<0.017
$\overline{1}$-MP (°)	-0.1589 P<0.189	0.1810 P<0.157	-0.2321 P<0.097
$\underline{1}$-$\overline{1}$ (°)	0.3921 P<0.012	0.1205 P<0.252	0.4586 P<0.004
$\underline{1}$-NA (mm)	0.4045 P<0.010	0.2157 P<0.114	-0.1594 P<0.188
$\underline{1}$-NA (°)	-0.4985 P<0.002	-0.1047 P<0.281	-0.3524 P<0.022
$\overline{1}$-NB (mm)	0.0103 P<0.477	-0.0691 P<0.351	-0.2929 P<0.049
$\overline{1}$-NB (°)	-0.118 P<0.268	0.0010 P<0.498	-0.2776 P<0.059
SNA (°)	-0.1231 P<0.248	-0.1513 P<0.200	-0.1145 P<0.263
SNB (°)	0.1199 P<0.253	0.0927 P<0.304	0.1372 P<0.223
ANB (°)	-0.2950 P<0.048	-0.2999 P<0.045	-0.3323 P<0.029
Pal.Pl.-SN (°)	0.2089 P<0.122	0.2346 P<0.094	0.0785 P<0.332
Occl.Pl.-SN (°)	-0.0142 P<0.469	-0.2588 P<0.073	-0.1324 P<0.231
MP-SN (°)	0.1394 P<0.220	-0.1960 P<0.137	-0.0775 P<0.334
N-Me (mm)	-0.1362 P<0.225	0.1940 P<0.140	0.2261 P<0.103
UFH (mm)	-0.0321 P<0.430	0.3323 P<0.029	0.2463 P<0.083
LFH (mm)	-0.1711 P<0.170	0.1144 P<0.263	0.1579 P<0.190

APPENDIX TABLE 36

Correlation of Overjet (OJ) and Other Cephalometric Measurements

Cephalometric Measurements	Before Treatment and After Treatment	After Treatment and Long Term	Before Treatment and Long Term
$\underline{1}$-SN (°)	0.3402 P<0.026	0.3448 P<0.025	0.5144 P<0.001
$\overline{1}$-MP (°)	-0.1219 P<0.250	0.0243 P<0.447	0.1314 P<0.233
$\underline{1}$-$\overline{1}$ (°)	-0.1639 P<0.181	-0.3823 P<0.014	-0.4849 P<0.002
$\underline{1}$-NA (mm)	0.3254 P<0.032	0.3505 P<0.023	0.4448 P<0.005
$\underline{1}$-NA (°)	0.2767 P<0.060	0.4104 P<0.009	0.5274 P<0.001
$\overline{1}$-NB (mm)	-0.1802 P<0.158	0.2724 P<0.063	0.3326 P<0.029
$\overline{1}$-NB (°)	-0.0766 P<0.336	0.0623 P<0.365	0.0976 P<0.294
SNA (°)	0.2131 P<0.117	-0.1340 P<0.229	0.0363 P<0.421
SNB (°)	-0.2994 P<0.045	-0.5530 P<0.001	-0.332 P<0.029
ANB (°)	0.5596 P<0.001	0.4823 P<0.002	0.4611 P<0.003
Pal.Pl.-SN (°)	0.0577 P<0.375	-0.2877 P<0.052	-0.2138 P<0.116
Occl.Pl.-SN (°)	-0.0841 P<0.321	0.1810 P<0.157	0.0248 P<0.445
MP-SN (°)	-0.1389 P<0.220	0.2543 P<0.077	-0.0104 P<0.477
N Me (mm)	-0.0212 P<0.453	-0.3782 P<0.015	-0.3668 P<0.018
UFH (mm)	0.0501 P<0.391	-0.2554 P<0.076	-0.2627 P<0.070
LFH (mm)	0.1291 P<0.237	-0.3054 P<0.042	-0.3906 P<0.012